ADDRESSES
TO
ENGINEERING STUDENTS.

EDITED BY
WADDELL & HARRINGTON
CONSULTING ENGINEERS.

SECOND EDITION,
EIGHT THOUSAND COPIES

PUBLISHED BY
WADDELL & HARRINGTON,
KANSAS CITY, MISSOURI.
1912.

The Schooley Stationery Co.
Printers & Lithographers
Kansas City, Mo.

$1.00

PREFACE.

For some time the compilers of this work have been considering the advisability of editing and publishing the papers of which it is composed, although from the very start they were firmly convinced of both its necessity and the great amount of good that it is capable of accomplishing for the engineering profession. Finally, in February, 1911, in order to settle the question, they sent a circular letter to some six hundred and fifty instructors in American and Canadian engineering schools requesting their opinions, which later proved to be almost unanimously favorable. This letter asked not only each professor's idea concerning the advisability of the publication; but also whether he would use the work as a text book and, if so, how many copies per annum would probably be required for his classes. While the number thus ascertained to be needed was not as great as might have been desired, it was large enough to warrant the Editors in undertaking the work.

Just here it is pertinent to mention that the compilation has not by any means been undertaken as a money-making venture—far from it!—because the Editors have not only done gratis all the work involved in its preparation, but also have themselves paid the cost of typesetting and providing the plates, in order that the book may be sold to engineering students at the actual cost of paper, press-work, binding, and distribution, the latter being reduced to an absolute minimum by cutting out all possible profit thereon. This has permitted of the book being sold to students of engineering, when ordered in large quantities, at seventy-five cents per copy and to the general public in single copies at one dollar. The Editors were guided in this action by the following reasons:

First. They want the book not only to be widely read but also to remain permanently for reference in the libraries of those who read it.

Second. As the compelling of students to purchase an additional text book is looked upon by some persons to be in the nature of an imposition, it appeared advisable to minimize to the utmost the gravity of such imposition.

In preparing the book the Editors have been governed by no sordid nor selfish motives, but solely by their desire to aid the stu-

dents of engineering and young engineers to make the best of their opportunities for development and progress, and thus eventually to benefit the profession.

The Editors were led to the issuing of the book by the recognition of the following facts:

"**First:** Most students who enter technical schools have no adequate idea of the standing of the engineering profession nor of its importance to the world; and the already excessive demands upon the instructor's time make it very difficult for him to impart much information along these lines.

"**Second:** As a rule, mainly because of the excessively large classes that engineering professors have to teach, students are not given sufficient friendly advice concerning how to make the most of their course of instruction, and are not taught how to study to best advantage.

"**Third:** For the same reason, students usually are not taught enough about ethical matters for their guidance both at college and in practical life afterwards.

"**Fourth:** With a few notable exceptions, students generally are not instructed at all adequately in good, sound, forcible, engineering English."

The reader will notice that many of the "Addresses" have been prefaced with editorial notes telling in certain cases who the writer is or was, and for what special purpose the address was prepared, besides pointing out and emphasizing a few of its most salient or important features. No apology is needed for this prefacing, because such notes should certainly prove both interesting and valuable.

The following quotation from the Editors' before-mentioned circular letter will indicate their object and the methods by which they hope to attain it.

"Our desire is to catch the freshmen as they enter, tell them what a great and important profession engineering is, inform them as to what they must do in order to obtain the greatest amount of value from their technical course, rouse their enthusiasm for study and work, develop in them high ideals in respect to ethics and accomplishment, and encourage them effectively to use their utmost endeavor to make themselves a credit to both the college and the engineering profession.

"Please note that the book could be used as a text book throughout the entire engineering course, some of the papers applying specially to the completion thereof and to the starting of the engineer's life work.

"As the papers of which the book would be composed are written in excellent English, the instructors in that language could employ it to good advantage as a text book or book of reference. We firmly believe in the importance of instructing engineering students in good, modern, engineering English, instead of teaching them mainly from the ancient classical literature."

No apology is needed for the omission of portions of certain papers, for the parts thus elided either were not of special interest to students, or dealt with matter treated fully elsewhere.

Anyone who reads the book from cover to cover (and the Editors earnestly hope that there will be many of its readers who will do so) will undoubtedly find that some points have been discussed by more than one of the writers, thus involving more or less repetition; but this is not objectionable, because such points are generally of great importance, and their reiteration simply adds emphasis to the statements. An agreement of authorities on any subject will tend to convince the reader of the correctness of their opinion and to impress it forcibly on his mind.

Occasionally it may be found that the authorities disagree; and in such cases it will be necessary for the reader to form for himself his own opinion. However, on all essential matters the various writers will generally be found perfectly in accord.

The numerous addresses composing this volume are arranged in the order in which the Editors deem they may most advantageously be read by students of engineering. If the book were used as a text, the first eleven addresses might pertain to the work of the freshman year, the next seven to that of the sophomore, the next seven to that of the junior, and the remainder to that of the senior. Such a division is merely suggestive and need not be followed. The earnest freshman student who desires to obtain the greatest possible benefit from his course of instruction and who has ambition to succeed later in the profession and make a name and a position for himself therein, will probably read the book from Preface to Finis, then will begin to study it anew, and will continue to review it during his entire course. If he does so, he cannot fail to be greatly and materially benefited by its perusal and study. In fact, the Editors feel confident that such a use of the book will often eventually prove to be the determining factor between success and failure or mediocrity in the reader's professional career.

Recapitulating, the Editors beg to express the hope, and even the conviction, that this compilation of addresses will result to an

eminent degree in the following benefits to students of engineering and young engineers:

A. Directing students into right lines of thought and action during their college course.

B. Encouraging students toward the ethical life both before and after graduation.

C. Development among students of a love for the engineering profession.

D. Giving to students a true and adequate conception of the scope and dignity of the engineering profession.

E. Enabling students to obtain the most profit from their technical course.

F. Improvement in students' and young engineers' knowledge and command of the English language.

G. Enabling graduates to develop themselves rapidly, thoroughly, and successfully in their professional careers.

H. Finally, though perhaps indirectly, benefiting the engineering profession ethically and in many other ways.

If these results ever be accomplished, even in a minor degree, the Editors will feel amply repaid for all the work which they have done in thus resurrecting (oftentimes from oblivion) the valuable and interesting papers of which this volume is composed.

J. A. L. Waddell,
John Lyle Harrington.

Kansas City, Mo.
April, 1911.

PREFACE TO SECOND EDITION.

It has been very gratifying to the Editors of this book to learn that within three months of the issue of the first edition, which consisted of three thousand copies, the supply has been entirely exhausted, and mainly by bulk orders from engineering schools. The reviews in the technical press have been the means of effecting a small demand for single copies; but as yet there has not been made any attempt to advertise the book among young practicing engineers, to whom its perusal would certainly be very beneficial—as has been pointed out with emphasis in several of the said reviews.

While the response from the technical institutions as a whole has been quite satisfactory, it has been noticed that a number of the leading engineering schools have merely ordered a copy or two for the library, and have not complied with the Editors' request to arrange for purchasing the book in bulk and selling it without any distributing profit directly to the students.

The editors feel that, considering the facts that they have edited and published the work by the expenditure of much of their time, energy, and cash, and are trying to distribute it to students at the actual cost of paper, press work, binding, and freight, with the sole object of benefitting the engineering profession through its embryo members, and that they are asking the professors to sell the books first and remit the proceeds afterwards, they ought to be warranted in anticipating that each university, college, and school where engineering of any kind is taught will arrange to distribute the books as suggested. If the Editors were millionaires, they would gladly provide a fund by means of which each entering freshman engineer-student throughout the entire country should receive a complimentary copy; but, alas!—no engineer can hope ever to attain to such wealth as would warrant a perpetual gift of that description.

That the Editors are not chimerical in their hope and expectation of the ultimate good to the profession which may be attained by this work, is proved not only by the reviews but also by numerous letters from engineers and professors of engineering, as well as a few from engineer-students.

The second edition contains five additional papers, incorporated in the following order:

The Development of Engineering as a Profession in the United States, by Dr. Charles H. Snow.

The Story of a Lighthouse, by Dr. A. J. Du Bois.

The Opportunities in the Electrical Business, by Dean George A. Damon.

Formulas, Their Uses and Abuses, by Dr. Alfred Hume.

The Elements of Effective Education, by Professor John Lane Van Ornum.

Each of these papers has been introduced by an editorial which gives the reason for its inclusion. The Editors believe that all five are of special importance and that they will prove interesting to both engineering students and young engineers in practice.

Strictly speaking, the papers of Dr. Snow and Dr. Du Bois should have been placed near the beginning of the book, as they should be read by freshmen; but this would have involved considerable labor and expense, thus militating against the Editors' desire to keep the selling price of the book down to an absolute minimum. All five of the new papers might have been inserted in an "Appendix"; but as the Index had to be rewritten to include the new matter, it was decided to place the additional papers before the two closing addresses of Professor Karapetoff.

In accordance with a criticism contained in the review of Engineering News and with the suggestions made in letters from a number of leading educators and engineers, the Editors have elaborated somewhat their introductions to the different addresses by telling a little concerning the professional careers of the authors thereof. These biographical notes are, of necessity, rather meagre and condensed, nevertheless it is hoped that they will prove of interest to our readers.

The Editors had hoped to be able to reduce the bulk price of the second edition below seventy-five cents per copy, but this new matter and an unexpected increase of five cents per copy in the cost of the first edition, made at the last moment by the printers, have prevented.

It is the hope of the Editors that, for a long time to come, there will be issued a new edition of gradually enlarging numbers each year; but they feel that, with the exception of a single paper, the book has reached its limit in size, unless the price be increased, which, in their opinion, is inadvisable. That exception is an as-yet-unwritten paper on "Engineering Ethics," which they trust they will some day be able to incorporate as an "Appendix." That a satisfactory treatment of this important subject will sooner or later be produced they feel assured; and when it is, they will certainly, if permitted, add it to this collection of addresses.

J. A. L. WADDELL.
JOHN LYLE HARRINGTON.

Kansas City, Mo.
February, 1912.

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THE PROFESSION OF ENGINEER.

By

The Editors.

Most young men when entering technical schools have no adequate conception of what the engineering profession really is. Many of them undertake the course either because their parents desire them to receive a useful education or because they think that engineering is a good calling in which to make a living; but very few of them enter on account of a heartfelt admiration of engineering as the profession of progress, to which are due practically all the wonderful developments of the world during the last one hundred years—developments that have so added to the comforts and conveniences of man as to make life truly worth living instead of a burden grievous to be borne.

A perusal of the succeeding addresses, of which this book is composed, will certainly acquaint the reader with the vast extent, the magnificence, the great achievements, and the wonderful possibilities of the engineering profession; but such perusal would require considerable time, and it is important that each entering freshman in technical schools obtain with the least possible delay some conception of the profession in which he is about to engage, hence the Editors have prepared this short paper for that purpose.

The most widely accepted definition of engineering is that of Tredgold made nearly a century ago, viz.: "The art of directing the great sources of power in nature for the use and convenience of man," and it is difficult to improve upon it, though numerous writers from time to time have made the attempt. Dr. J. James R. Croes wrote that "engineering treats of the intelligent direction of the laws governing matter, so as to produce effects which will reduce to a minimum the time and physical labor required to supply all the demands of the body of man and leave more opportunity for the exercise of the mental and spiritual faculties." This, too, is a good definition of engineering; but it is incomplete.

Another definition might be given thus: "Modern engineering is a combination of science and art by which all strictly material productions that involve construction, either directly or indirectly, and which are serviceable to mankind, are evolved, designed, and materialized."

To prepare a complete detailed statement of what constitutes the entire field of engineering would be a Herculean task that it does not appear wise to attempt in writing this paper; nevertheless an endeavor will be made to list as thoroughly as practicable the principal types of construction and activity which pertain to the different branches of the profession.

Half a century ago there were only two divisions of engineering —civil and military, but later the former was divided into four groups, and during the last two decades the tendency has been to divide and subdivide the profession until the representatives of each little craft now claim a specialty of their own. The four groups referred to are civil, mechanical, electrical, and mining engineering; but no one of them is totally distinct or separate from the others, because many constructions involve two or more branches of engineering. For instance, the modern bridge with movable span, which most people would consider as belonging to the realm of civil engineering, involves mechanical engineering in the design and construction of its operating machinery and often electrical engineering in the production and use of the power required for operation. Again, in the development of a mine, which is generally conceded to pertain entirely to the line of mining engineering, civil engineering is needed in making the surveys both above and below ground, in the transportation of materials by intra-mural railways, and in many other ways; mechanical engineering is involved in designing the pumps and other machinery; and electrical engineering is applied in the production of their operating power. In truth, all the divisions of engineering are so closely allied that it is impossible to disassociate them; and, on this account, a really up-to-date engineer, while trained thoroughly in all that relates to his special line of work, must have a broad, general knowledge of all the other lines.

Civil engineering, as understood today, includes all kinds of surveying from the simplest land surveying to the complicated and accurate Coast and Geodetic work; the design and construction of bridges; extensive and difficult foundations; tunneling; retaining walls, sea-walls, and other heavy masonry; viaducts; ocean piers; lighthouses; wharves; docks; river improvement; irrigation; harbors, jetties, and other waterways; levees; water-supply; sewerage; filtration; treatment of refuse; highway construction, including roads, streets, and pavements; canals; dams; ordinary railways (both steam and electric); inclined cable railways; gas-works; the general design and construction of all plants (steam, electric, hydraulic, and gaseous); the general design and construction of cranes; cableways, break-

ers, and other mining structures; the heavier structural features of office buildings and other large buildings that carry heavy loads; mill buildings; the general problems of transportation, quarrying, and handling of heavy materials; reinforced concrete constructions of all kinds; and the testing of nearly all the materials used in engineering practice.

In contradistinction, mechanical engineering includes the design and construction of steam engines; gas and gasoline engines; automobiles; locomotives; aeroplanes; steamboats; machine tools; hoisting and conveying machinery; pumps; turbines; the machinery of movable bridges; elevators; cranes of the usual types; rolling mill machinery; blast-furnace machinery; and all other machinery for purely manufacturing purposes.

Electrical engineering includes all kinds of electrical work, such as the designing, construction, and operation of telegraph and telephone lines; the electrical portion of railways; electric light plants; dynamos; motors; switch-boards; wiring; electric devices of all kinds; transmission lines; cables (both marine and land); and storage batteries.

Mining engineering includes shaft-sinking and all other underground mining work; means for handling the products of mines; roasting, smelting, milling, stamping, and concentrating of ores; drainage and ventilation of mines; disposal and utilization of mine refuse; and similar problems.

If these items are not sufficiently numerous, it may be mentioned that the engineer is beginning to monopolize some of the work of the architect and of the chemist, such, for instance, as the design and construction of the main features of large buildings and the practical chemical work of important manufactories.

A perusal of the foregoing list of engineering works (which is by no means complete) ought to convince anyone concerning the vastness, grandeur, and importance of the engineering profession. Can its votaries be blamed for claiming that it is by far the most important of all the learned professions, that it is also the most scientific of them all, and that the wonderful progress of mankind during the last half century or more is due essentially to the energy and ability of engineers?

If each freshman student as he enters his technical course will recognize and consider the wide field which his chosen life-work covers and its importance to the human race, one of two things will happen—either he will be so discouraged as utterly to lose heart, or he will be aroused to enthusiasm and, in consequence, will coura-

geously and firmly determine to do his best to make himself a worthy member of the engineering profession. In the first eventuality he will do well to drop out of the race at once, because every successful engineer is of necessity a man of courage, and because weaklings are not wanted in engineering; but in the second, if he continue firm in his resolve, his studies and work will soon become a true pleasure to him, and, barring accident, he will be practically certain eventually to attain as great a professional success as his personal ability and limitations will permit.

ADVICE TO FRESHMEN.

By

Francis C. Shenehon.

Dean Shenehon, of the College of Engineering of the University of Minnesota, very kindly offered the following paper, previously given by him as a lecture to the Freshmen of that institution; and the Editors feel truly grateful to him for his courtesy and valuable assistance. This is one of the most important papers of the book for the entering Freshmen, as it tells them what they may wisely do and what they should not do during their course. Any student who follows Dean Shenehon's advice is certain to profit greatly thereby, hence it is hoped that our readers will pay special attention to this paper.

Francis C. Shenehon was born in Brooklyn, N. Y., on December 20, 1861. He received his earlier education in the public schools of Brooklyn, completed his college preparatory work at the Minneapolis Academy, and received his collegiate training at the University of Minnesota. His first work after leaving college was on the preliminary and location surveys and the construction of the "Soo" Line connecting Minneapolis and Sault Ste. Marie. After the completion of that railway, he engaged in general practice at Sault Ste. Marie. From 1891 to 1898 he was employed on the extensive River and Harbor works of the St. Marys River, including the building of the great Poe ship-lock. It was during this period that the hydraulic investigations of the Lake Survey were begun, and Mr. Shenehon took part in the work on St. Marys River. In 1898 he began work on the hydraulics of the Niagara River as part of the project to regulate and control the Great Lakes, and in 1901 he began the investigation of the hydraulics of the St. Lawrence River. From 1902 to 1906 he was engaged in hydrographic work in the resurvey of the Great Lakes; and at the beginning of this period he revolutionized hydrographic methods for navigable ways by the invention of the Tension Wire Sweep. When the question of the destruction of Niagara Falls by the continued withdrawal of water for power purposes was raised, Mr. Shenehon directed the extensive hydraulic examinations for the United States. The investigations made in this project for the preservation of Niagara Falls, and his prior work on the Niagara and St. Lawrence Rivers, rank among the most extensive studies ever made in River Hydraulics. In 1906 he became Principal Civilian

Engineer of the United States Lake Survey, and directed the work of the Resurvey of the Great Lakes and the continuation of hydraulic work in the St. Clair and St. Marys Rivers.

In 1909 he was made Dean of the College of Engineering of the University of Minnesota.

Mr. Shenehon in his capacity of hydraulic engineer has served more recently as Engineering Counsel for the United States in the extended litigation regarding the Chicago Drainage Canal, and in the Condemnation of the Water Powers of the St. Marys River. He is a member of the American Society of Civil Engineers.

Editors.

ADVICE TO FRESHMEN.

By

Francis C. Shenehon,
Dean of the College of Engineering,
University of Minnesota.

Gentlemen of the Freshman Class:

A custom has become established here which makes it the duty of the Dean of the College of Engineering to call together the freshmen early in the year, in order that matters which are vital to success in college work may be clearly presented to them at the outset.

In compliance with this custom we are together to-day, and it is my great pleasure to welcome you and to begin to know you. Primarily, I want to congratulate you upon your choice of a profession and upon your great chance in life. It is only a chance, an opportunity, thus far. You have won entrance to this College—that means up to now work well done. Undertaking work in the College of Engineering shows courage, for only strong men knowingly enter here where the portion is man's work. No mollycoddles may hope to prosper here. You have entered a course so strenuous that success in it will call for every fiber of manliness you possess—all your pluck and endurance. You are, therefore, a body of picked men, each one of whom has the rare opportunity of completing the course and of taking up the practice of the most virile of the professions—that of the Engineer.

I do not hesitate to tell you frankly at the outset that the task before you is not child's play or boy's work, because if any one of you does not thrill at the prospect of a stiff fight or of a swift race, he is not of such stuff as Engineers are made of—he is not in the right group. It is fine to be strong enough to conquer and swift enough to win; but the strength needed is not all brute strength—far from that—and the swiftness is not all speed. There is an element of persistence in winning a race, and an element of skill in conquering. You have already given evidence of your ability to conquer and to win, and you will succeed, provided your path trends aright, and provided you keep eternally moving.

A college education is the privilege of but few men. About one man is college-bred to eight hundred who are not. This makes the distinction a high distinction, and I trust each man here will resolve to

go on unswervingly to the commencement day that will place him in this privileged class of college-bred men. It is a long distance through life. Many of you have fifty years of the journey yet before you. Do you not think these many years will be sweeter and fuller to you if you carry the consciousness of adequate educational training? Do you not think you will be better citizens, more helpful to your own kin, to your community, and to your country? Do you not think that trained hands and minds will enable you to raise in some measure the well-being of the many who have not the training which the present promises you?

I wish to place much stress upon the value of the chance now yours, because I want you to make the most of it. You must make good, you must realize the hopes for you of those at home, you must make worth while the sacrifice made by your people for you. Do not disappoint the mother and father. Live up to what the neighbors expect of you, and graduate with honor. Do you know that out of a freshman class of a hundred men, on an average only forty graduate while sixty drop out for one reason or another? Resolve that you are in the game to the end, and that you will not quit.

You have doubtless heard that Minnesota plays football. The Maroon and Gold has a splendid chain of victories on the gridiron. The games will be on soon, and you will glory in the wonderful work, the speed, skill, and endurance of the team. Each man is working like a tiger to maintain the prestige and honor of the University. The rallying cry of our athletics is "Minnesota never quits!" Make that your own battle cry as you proceed in your college work, not in the field alone, but in your studies, in the class room, and in life. When you feel disheartened and weary of the eternal grind of human endeavor, grit your teeth and say "Minnesota never quits." The world cannot defeat a man who lives up to that obligation.

I wish you would note the fact that I am addressing you, not as boys but as men. You are treated here as men. You have been passing through various stages of evolution, but now for the first time, so far as your schooling is concerned, the obligations and responsibilities of manhood rest squarely on your shoulders. The first stage of the educational journey is upon the low level plain of the grade schools, and the peculiarity about the travel across this plain is that it is compulsory. The law compels parents to give their children this part. The state wants her people to have at least that amount of education, the rudimentary part, to avoid gross ignorance and the resulting evils to the social structure. You are compelled to go on with it whether you wish or not. If you do not behave yourselves, if you do

not study, you are disciplined, but you have got to go on just the same. Now, the second stage is somewhat higher. You are on ground that overlooks the first low plain. This is the High School, and here also it is desirable that you go on and graduate. It is desirable that you graduate from High School whether you have the distinctive mental characteristics or character that will give you the highest success in life as a professional man, or not. The average citizen—and any citizen—is better off for his High School course, and therefore the policy of the state and of the city is to urge men to go on with this part of their educational training. After you have passed over this plain and have entered the University, you have stepped up to a high tableland where the conditions are very unlike those in the two thickly populated plains which you see spread out below you. On the two lower plains you were first the *child* and then the *boy,* and now you have reached this splendid tableland where the air is clear and invigorating, and you are the *man.* Most of your schoolmates of the earlier school days are not here. The wage-earning activities of life have absorbed them. They have taken up the burden of *men,* but have missed your special privilege of dwelling for some years in the rare atmosphere of the academic plateau.

Now, whenever anyone has a privilege, he has something which exists only at the expense of others. We have heard much of the special privileges enjoyed by manufacturers, who are favored by tariff schedules which enrich them but leave the masses poor indeed; we have heard of corporations whose special privileges, in the form of municipal franchises for gas or street car traffic, make great dividends for them at the expense of the people. Your special privilege is that you are becoming mentally enriched and equipped with professional training —at the expense of the state. Well, the state, so far as its money is concerned, is made up of people; and all the people of the state who are property owners are paying your expenses. Your townspeople, your neighbors, are paying good serviceable, sacrificial dollars, that you may have the special privilege of these years of training to make you abler citizens. It does not follow that there is any immorality or unfairness in the special privilege which the state has conferred upon you. That depends upon whether you do your work and accomplish the results aimed at in conferring upon you the privilege. For example, a street car company in a great city holding a valuable franchise for the use of the city streets, may give such excellent service at minimum rates that the special privilege (which another company might use to loot the public) becomes a special blessing. The tax is returned to the people with interest. If you regard your special privilege to expend

the money of the people of the state for your education as a trust imposed upon you, and if you return at the end a capable, serviceable, educated Engineer, the investment has been worth while, and your special privilege has been transmuted to a special blessing.

Your relation to the state is, therefore, such that an implied contract exists. The state says: "In consideration of John Doe's doing each year certain work in accordance with the specifications of the University of Minnesota, which will convert him into a competently trained Engineer, the state will expend upon him three hundred dollars per annum for the term of five years, etc." If you fail to do your part in this contract, of course the state cancels the agreement, you lose your special privilege and leave the University. You must understand that the petty fees paid by you do not care for a fifth part of the cost of your education.

I am stating this business relation between you and the state in considerable detail, because you are men, and will feel the obligation of a business agreement. Your professional life will be made up of agreements and fulfillments, and you will wish to begin your life as an honorable business man by meeting your obligations squarely here at the outset. Where a man receives money from his people for his living and other expenses, a second implied contract exists with his people, to perform his work so as to do credit to them.

You must understand that while our Engineers on the Campus are earnest, strenuous workers for the most part, now and again men appear without the business perception to live up to their contract. For these we have a pneumatic gun into which they are gently loaded and tossed into the uttermost realms of thin air. Do you remember the projectile which Jules Verne conceived for the trip from the earth to the moon? That had water compartments, as I recollect it, with collapsing bulkheads to absorb the starting shock. Well, our projectile has no collapsing bulkheads.

It will be well for you to understand the organization of the University, its parts and their relations, its administration, and the attitude of the members of the Faculty toward you. The University is now a complex organization of ten colleges. In the beginning the whole University was made up of a single college, with a President but no Deans. As it grew larger it separated into Colleges, each college organized much like the original unit. The Deans are the executive heads of the Colleges, while the President is the Chief Executive of the University. Of course there is a business department for the handling of moneys, the purchase of supplies, and for keeping the accounts; then there is the Registrar who keeps the student records; and a Super-

intendent of Buildings and Grounds. Above all are the Regents, who meet about once a month and act as the Directors.

The College of Arts ranks first in seniority and the College of Engineering second. Within the College of Engineering are the various departments, as the Civil Department, the Mechanical Department, the Drawing Department; and each department has its head and its associates. Now the Faculty exists to direct you, to instruct you, and to serve you in every way it may, to the end which the state has in view in educating you. It may astonish you to find out how kindly each member of the Faculty feels toward you. Each member is a friend and an older brother. You will have every consideration as men; you will be treated with justice always, patience generally, and malice never. You must reciprocate and be kindly and considerate, just in your judgments always, vindictive and revengeful never. Sometimes you will not view things as your instructor does. In such cases you must be open-minded enough to feel that when your judgment conflicts with that of your instructor, the chances are that the older man is right and that the younger man is wrong. This is not always so. Age does not make men infallible. When you feel certain you are right, discuss your case good-temperedly and fairly with your instructor, showing him the respect that is paid a judge in a court of law. You always have the right of appeal to the Dean of the College.

The Dean is your special counselor. He expects you to bring your troubles and perplexities to him for advice and untangling. In matters of College affairs or of life you may expect a sympathetic hearing. I am aware that life sometimes takes on a somber tone with young men, things go awry, conduct sometimes goes wrong, the threads get badly snarled. Sometimes a profound gloom invades a man's mind. Youth is not wholly blithe and shot with sunshine. But those who have passed through periods of depression know that things eventually prove not so irretrievable as they seemed. After a mistake it is well to remember:

"That men may rise on stepping-stones
Of their dead selves to higher things."

Should a midnight fog settle down upon any one of you, grope your way to my office and let me try a few rays of sense and sanity.

A story is told of a man who was stopping in a country hotel where the partitions were thin and the floors uncarpeted, and he was kept awake up to mid-night by a man in the next room who was pacing up and down. The annoyance finally became so great that he got up and knocked on the stranger's door and said to him, "My friend, you seem to be in some trouble." And the reply came in an agitated voice "Yes, I am; I owe a man, due tomorrow, one hundred dollars and I cannot

pay him." "Well," said the man, "you would better go to bed and let the *other man walk.*" Now, while that was not a full solution of the stranger's difficulty, it let a little sane sunlight in upon the situation. The man to whom the money was due, perhaps, was the proper man to worry under those conditions, although I do not wish you to infer from this that the obligation did not have its worriment.

The Faculty of the College is a legislative body made up of all professors and instructors. It deals with the construction of the curriculum, the formulation of rules and regulations, student discipline, and many other matters. Its decisions are wise in the main, and it gives full hearings in cases of importance. The Faculty has its committees like all legislative bodies, the Enrollment Committee which you have met, the Student Work Committee which you are likely to meet, and several others.

Remember that the Faculty is anxious to keep here and graduate every worthy man of you. Our College is stronger, more important, when we have greater numbers. Growth indicates a successful college in the eyes of those who judge us. But we are more interested in putting the brand of *Engineer* and *Minnesota* only on men whose work and character are such that they will reflect credit upon us. We must stand for quality—honor and competence—first, numbers afterward.

We all, and the Student Work Committee in particular, are anxious to keep every man in his class shoulder-to-shoulder with his mates. If you get behind in a subject, you are a cripple, you are not keeping step with the procession. It gives us trouble. We must consider you and doctor you. For this reason you may see that we prefer to give you a passing mark—it is easier for the Faculty. But we are charged by the state with the obligation to give no credits, except as they are fairly earned. You may rest assured of one thing. We will not cripple you, to penalize you. Our penalties will be constructive, not destructive. Since this corps must march in a body, it would not be good generalship to shoot a man's leg off when he flags. We will prod him with a bayonet and urge him to keep up. If, however, he does not keep up, he must join the troublesome crippled squad. This squad is a burden on the College; and our constructive policy is to keep it as small as possible. Do you know that in war time the wounded are a greater burden than the dead? The dead may be buried, but the wounded must have medical attention, nursing, and protection. Keep out of the crippled squad.

Now, I am going to give you a term to express the kind of men we desire as a product of this college. We want *"thorough-breds,"* and I

wish to tell you what a thorough-bred is as I mean it. Perhaps I can do this most quickly by telling a story. Governor Odell of New York related it. He said he was out hunting with his father one day, and they had with them an Irish setter which was a thorough-bred, and had also a yellow dog. His father picked up the yellow dog by the nape of the neck and held it out at arm's length, and the yellow dog whined piteously. He dropped it and picked up the Irish setter. The setter hung there with never a whimper. He said, "My son, that is the difference between a *thorough-bred* and a *yellow cur.*" Now, what the thorough-bred had was courage, self-control. It certainly hurt him just as much as it did the yellow cur, but he did not whimper; and self-control is the one thing that will let a man win out in life.

You are all familiar with the fact that each one of us, each man, is made up of two personalities. You probably have all, or most of you, read Stevenson's story of Dr. Jekyl and Mr. Hyde. Each of us is made up of the fundamental instinctive animal part which wishes to do things whether they are fair or not, and the regulative controlling part or personality, which we really think of as the "I". When you did not mean to do a thing, but you did it just the same, you were controlled by the beast, the brutal part of your make-up. The man who has himself in control is simply the man whose higher personality, the actual ego, rules the lower personality, rules the beast. It is a good thing to have a *strong beast* in you. That may be an element of strength in your character. The beast is the motive power. It is the thing that drives, but the higher personality must have this beast by the throat, absolutely control him, and make him do his work. In controlling your primal power you are first learning the work of the engineer. Now the *engineer by definition* is one who directs the forces of nature to the uses of man, and this powerful primative physical endowment is one of the forces of nature which every engineer must learn to control and direct early in his career, else his career will not carry him to great usefulness in life.

Now, you young men have come from the rural districts, possibly the farm, or else from the city. From whichever of these two places you have come, you have an element of strength in that fact. The man who comes from the farm brings with him the strong skeleton, the brawny muscles, the sound nerve, and the sane view of things which is characteristic of those not too many generations removed from the soil. On the other hand, the man from the city has the strength of finesse which comes from the urban life with its more complex relations and higher conveniences, and he comes also possibly from a generation or two of men who have used their brains

rather more than their hands for a livelihood. A generation of brain-workers makes furrows in the brain that help the generation which follows. To have had in the background of your ancestry some professional men may make your college work easier, and if you carry yourself aright you have on that account higher chances of ultimate success; but I want to warn the man who comes from the city, with his possibly smoother ways and more urbane manners, that unless he absorbs the strength, the good health, and the calm poise which the man from the farm brings with him, he is not going to compete successfully with the man from the farm. And, on the other hand, I want to warn the man who comes from the farm that unless he can gather to himself something of the urbane characteristics of the man I have been speaking about, in the competition of professional life he may not win the highest rewards. It follows that of the two classes of men, farm bred or city bred, each has an advantage of his own at the outset; and in the end the successful man, the man who will win our highest admiration, is the one who can blend strength and polish. It is the mailed fist under the glove of velvet.

Returning to the use of the word *"thorough-bred,"* which I wish to be thickly strewn throughout this talk, I want to say that the kind of thorough-bred I am talking about is *not* of *distinguished lineage*. I do not mean men whose ancestors came over on the Mayflower,—because it has been pointed out that the ocean liners of to-day offer better facilities for crossing to our shores,—but I mean men who, when they leave our institution, have this combination of strength and urbanity.

Now, there are certain things in your college course which I wish to bring into high prominence. An engineer in his direction of the forces of nature is an expert mathematician, applying to useful ends his mathematical attainments. The backbone of the engineer is mathematics; and you men, if you are going to succeed in your college course, must get a firm grip on your mathematics, and clear up everything as you go along. To get behind in mathematics is fatal. Other courses depend on it. Your Physics of the Sophomore year and your Mechanics which comes later require higher mathematics as a prerequisite. If you have failed to pass or are conditioned in your mathematics, you are at a serious disadvantage; and I advise you in the strongest terms to get your mathematics right. You are building a pyramid, and in the first course of masonry lies your Freshman Mathematics. You cannot lay your second course of masonry until the first course is completed. The Sophomore Mathematics is in the second course of masonry, and on top of this comes Physics, and another course is Mechanics. Bye and bye you get to the upper levels of the pyramid

wherein your structural work, your bridge design, your machine design, are the masonry courses. But you cannot lay these upper courses, and you cannot do your work in life as an Engineer, unless the bottom courses form a safe and adequate foundation. If by chance you should be conditioned in mathematics,—and quite a few men are—make it your first duty in life to get that condition off. Do not let the thing run on. Do not let it stand. One of the delightful characteristics of youth is to put off unpleasant things, but the thorough-bred we have been talking about *does the thing,* and does it *now.* In case you should be so unfortunate as to get a condition in mathematics, work it off as soon as possible.

Now, I have spoken first of mathematics because it is of pre-eminent importance, but I want you to consider that the maintenance of the highest scholarship is incumbent upon you in all your studies.

It is incumbent on Engineers to become versatile, cultivated men. If we cheapen ourselves by avoiding or slurring those subjects which educate us as men, because we cannot see that they aid us as bread-winners, our profession is but little more than a trade. We will receive lower money returns than lawyers and surgeons, and our opportunity for high service will be lessened.

Because our profession has so recently emerged from the trades, our culture is questioned. Many people do not distinguish between a locomotive engineer, and a Mechanical Engineer. If you are satisfied with the wages of a trade, you will not need to speak and write clearly and effectively, you do not need to study English and German or French—but you cannot graduate at Minnesota! This is not a trade school but a professional school. You will need to do just as conscientious work in Rhetoric and Language as in your technical studies. We want Minnesota Engineers to reach the high ranks of the profession, and not pass through life as subordinates. You will be useful men as subordinates, but there is something more useful and better. You find it hard to believe that language studies will help you as Engineers, but take this on faith now, and make your scholarship excellent in them. That these will count, accept as expert judgment.

Your studies come first in importance but there are outside activities which are alluring and useful. I shall advise you to have some part in them, but always under the limitation that you have kept your scholarship high. But this high scholarship that I ask of you will not be realized unless you have a clear comprehension of yourself as a cutting mechanism. You cannot expect a dull tool to do keen cutting, and you cannot expect a dull mind to do easily and rapidly the scholastic work presented to you young men. You should find out early in the day how

to keep this beast that I have spoken of in high, vigorous condition, and how to keep this controlling will in high, fine condition also.

First of all, keep yourself in good physical trim. You must have enough to eat. You must eat wholesome things. You can not expect such an engine as you are to do work without the proper fuel. Then you must get the proper sleep. Do not let any fairy tales about Napoleon's capacity for work on six hours' sleep lead you to burn too much midnight oil, because the more accurate historical fact is that Napoleon needed his eight hours' sleep the same as the rest of us men. Consequently, get your regulation sleep, and your brains will be sharp like cutting instruments. I read in a magazine not long ago that there is a physiological reason why a man must have his eight hours' sleep as a minimum. I will not vouch for its scientific accuracy, but I give you the statement as I read it. During the waking hours the high activities of body and brain create certain impurities in the blood which act as narcotics, or drugs on the brain. In the end this produces sleep. Before the sleeping condition comes there ensues a tired feeling, and that tired feeling simply means that you have an excess of poison in your system. Your brain will not work well under this condition, and you should not expect it to, any more than if you had taken a drug, and the drug was influencing you toward weariness and sleep. During the night time, the brain being at rest and the muscles at rest, the lungs go on pumping and the blood taking on oxygen, the poisoned condition disappears, and the man awakens full of vigor with a keen-edged mind. You gentlemen will be just as foolish if you do not get this full amount of sleep as you would be to work and expect to accomplish good results with a dull tool.

You need some exercise, and that has been provided for the most part, in your drill; but you ought to get out and breathe the open air some minutes or an hour daily; and you ought to absorb the sunshine into your blood and get the wind into your pulses, in order to keep yourself in the best possible condition. If, however, you overdo this matter of physical exercise, you use up the energy which you need for proper study. Therefore, the rule for exercise is "Not in excess, just in moderation." Now, the *beast* in us would wish to carry exercise to excess because it is sweet to the physical sensation, but the controlling power which marks the thorough-bred will not permit this, as it will not permit any excess. Even in matters of eating, things taste so good that it is pretty difficult to eat with the moderation that is best, and here again the controlling personality of the thorough-bred will regulate. A man can be just as much of a sot in his eating as some men are in their drinking.

I am not going to say much to you young men about drinking, because I am certain it is not necessary. We business men look upon a man who drinks as a fool, as a yellow cur. The "whiskey breath" warrants discharge from a man's position in many corporations in this country, and it discredits a man almost everywhere. As you young men by coming to this University have given evidence of intelligence, I trust you have no illusions as to there being anything manly about drinking. I give you my full assurance that, acting as the employer of many young civil engineers, I never advanced a man in salary or position who I knew had any drinking tendencies whatever. Having under my direction several steamers, I have not permitted on any of those vessels liquor anywhere; and I have done this not from any fanatical dread of liquor but simply because it was good business to exclude it. The intelligence of the man who uses liquor is questionable. We do not expect much from a man of that kind. Drinking is simply stupidity. A man whose brain is active does not need alcoholic stimulation.

Gambling is another thing which reveals a pauper mind. Men gamble for excitement. A dull brain which cannot find interest in the normal wholesome games and contests of life, must needs accent the excitement by money venture. Surely for young men full of the enthusiasm of youth, with young pulses and minds keen for interest in the kaleidoscopic life of the Campus, it is not necessary to indulge in vicious things, or things that would make them less worthy in the eyes of their townsmen and townswomen, in the eyes of the mothers and fathers. Get your pleasure in wholesome ways that refresh but do not demoralize.

In my life as an Engineer on the frontier, at the end of a railroad line under construction, where all sorts of adventurers preyed on the wages of the laborers, I have seen professional gamblers at work. I know how dishonest the games are and how degrading and pauperizing the practice is. In a railroad terminal I have seen men cheat in a game where detection would have meant death. I have seen adventurous young men leave their money there. I have never seen any consecutive winnings.

I am not going to do more than to touch on the social evil. It is a loathsome thing, repellant to clean men. I hope you will attend the special lectures on this subject to inform yourselves of the danger of any dalliance whatsoever. I trust the daintiness of healthy youth will steer you clear of the pest houses which are sometimes a lure to unintelligent, inquisitive young men.

As for tobacco, I would advise you to defer smoking until the Post Senior year. You will be older then, possibly wiser also, and may decide the matter for yourself with maturer judgment. Many good men smoke, many better men do not; some of the best men smoke, and some do not. We cannot separate the smokers and those who do not smoke, and find in the latter class all our best men, and in the former class all our poorer men. The mature man who smokes in fine moderation is not condemned by his fellows, but the man, young or old, who smokes to excess is an object of pity to clear-sighted men. Here, as in many other cases, the thing itself is insignificant, but its abuse lamentable. The firm grip on one's self which is the test of the man is needed in dealing with nicotine. Smoking costs money, can you not spend that money to better advantage, during your undergraduate days? Smoking takes the keen edge off the mind, do you not need that keen edge to cut your way through the manifold problems of your college work? Smoking sometimes dims the eyes; you need all the strength of your vision for incessant application to your work. It is prohibited in many of the best offices of Engineers, because it lessens a man's output, and vitiates the air for others who do not smoke. It is prohibited here on the Campus. Of the American Members of the Board of Consulting Engineers for the Isthmian Canal, not one smoked, and these were most eminent men. Smoking in moderation is not very bad, but for you it is not now worth while. The disadvantages are real, the advantages in good fellowship and relaxation are intangible. Smoking is really in the "twilight zone", between good and bad. The clear daylight is better for young men.

Now, it has been called to my attention that some young men coming to this institution have not taken the proper manly view regarding cheating—cheating in quizzes and examinations. If this is so, I apprehend that it represents nothing vicious in intent but a wrong conception of what is a good joke. Some men probably think that, if they get through an examination by means other than knowing the subject, it is a good grind on the professor; but I believe that a young man who takes this view of it would better think about it a little more seriously and wonder whether a habit of this kind, which endangers his reputation in his college life, is not likely to become a fixed habit in his later years, and whether he may not join the group which contains the yellow curs and not the thorough-breds. I do not think young men appreciate very fully the fact that character, known honesty and justice and kindliness, bring the highest money returns in our profession, but they do. The man who is known as the Dean of American Engi-

neers, Alfred Noble of New York, past-president of the American Society of Civil Engineers, Chief Engineer of the Pennsylvania Roads' East River Tunnel, earns his great salary and his great esteem no less by his known probity and justice than by his high administrative and technical ability.

At Ann Arbor a few years ago, at the University of Michigan, a man was found cheating. He was tried by a jury of his fellow students, adjudged guilty with a recommendation that he be suspended for a year; and I believe the offense committed fully warranted a humiliation as great as this young man received,—provided of course the offense were clearly understood. Let me make this matter entirely clear. In any of your exercises which is a test of your work, whether it is an examination, a quiz, or a theme, do not take help or give it. Do not take it because that is dishonorable, do not give it because that degrades your classmate, and in his dishonorable act you become an accomplice and are liable to the same treatment meted out to the culprit who received your aid. Do not be a good fellow to the extent of aiding and abetting a counterfeiter in passing spurious coin. You may be in doubt sometimes as to how far this applies. When in doubt do the franker thing. Err if at all on the safe side. Remember the adage, "If an egg is doubtful, it is bad."

I expect you have already chosen your boarding houses, and that you have rooms which have good air in them and excellent light. Do not attempt to drive your mind at its *best* pace and with its highest power in a badly ventilated room. Your lamp for night work should be a good one. I myself when at work like to be flooded with light. It appears to keep the brain cells active. You know light is wakening and darkness induces sleep. Poor light is less vivifying to the mental faculties than brilliant light.

You must assure yourself of reasonable quiet and freedom from interruption, if you would study effectively. Form the habit of absolute attention to the task in hand. Keep parallel all the forces of your mind in the direction toward which your work tends. Be master of your study hours, and do not permit any one to interrupt you. In "Tom Brown at Oxford" I remember they had a special oak door to close when a man was at study and was not to be interrupted. He was said to be "sporting the oak" and it was bad form to interrupt him then. When you have work to be done, do not hesitate so to inform your caller. Be courteous, but do not permit your study hours to be encroached upon. Be systematic. Keep your room, your books, and your papers in business-like order. Disorder in your environment will put disorder into your brain, and into your work.

Form the habit of the card index and the document file. Make of your room your office, and have it a business office. More time is lost in hunting up mislaid letters, papers, and documents than you can imagine. Special lectures will be given to you on "How to Study." In this you have an opportunity to prove yourself an efficiency Engineer. For five years now your task is to study. By bad methods you can accomplish too little to win high scholarship. By orderly, systematic, consecutive, incisive, effective work you may rank high and have time for some of the Campus activities that make the University life so delightful and inspiring.

Some of you have already pledged yourselves to Fraternities. Provided you are a thorough-bred, you may live in a Fraternity house and do good work. The good fellowship there is charming and valuable. You will be knit close to friends and brothers, who will endure through life. The friends you make in College stand apart, no others will be like them. But as fraternity men you will have diversions and activities which are likely to lower your scholarship below that of men who are not of the fraternities. You must not go into a fraternity unless you are financially able to do some things which outside men do not have to do. You will have to bear your share of the expense and this is sometimes not inconsiderable. Above all keep your friendships open. Do not tie yourself exclusively to a little coterie. Have your friendships as broad as the University. The fraternity men are generally a well-set-up, clean, personable lot of fellows, who wear good clothes and cultivate courtesy and good form. These things are well, and are the ways of the city bred. You must conform as far as you may. In some fraternities the upper classmen exercise the prerogative of elder brothers, they advise you, admonish you, and see to it that you do your work. In this element there is hope of great good.

We look for not only courtesy and kindliness in you men, but also for chivalry and good citizenship. You are in a way the guardians of our property here on the Campus. You wish to keep things fresh and presentable. The child of the grade school and the boy of the High School were sometimes young vandals, they delighted in breaking and marring things. They cut their initials wherever it was safe, they broke down the school fence, and carried away the gate. They broke the panes in the windows of the country school house. They did all sorts of boyish pranks and mischief. Now you are conservators and guardians playing the part of men. Foolish pranks in a College are to-day evidence of provincialism and low grade. When College men descend to mischief, they hurt the good name of the University, and make their own prestige less valuable.

As for chivalry and courtesy, treat each girl you know as a protective elder brother would. The most contemptible thing on earth is to degrade a woman. Let the College be known for its strong men and their fine courtesy. Touch your caps always to all professors. Never permit a woman to stand in a street car while you have a seat. There are only four reasons why a young man in a street car permits a woman to stand while he remains seated.

First—He is ill.

Second—He is a mollycoddle.

Third—He is a boor.

Fourth—He is not an Engineer.

President Taft was called the most courteous man in Washington, because he once gave his seat to *three* women.

As to what are known as College activities, do not hasten to get into too many things. No man can take part in half of the things going on and make good in the College of Engineering. You must choose with deliberation the things you may have a part in. Let me advise you when in doubt. It is your duty, and it will be to your profit to become a member of the Engineers' Society. Do that immediately.

You should organize as a Class a little later. Elect officers, and have a get-together banquet. Wait a little while, however, until you know your classmates well enough to bestow the honor of President wisely and worthily.

In closing I want to emphasize the high place and the high service of our profession of Engineering. It is full of the splendor of brilliant achievement. Its horizon is world-wide. It is modern and pulsing with the vigor of youth, yet is as old as the Pyramids. It is vibrating with this new life, yet it deals with laws ages old when this earth was born. It is a profession of help, of service, of betterment. It builds, and old earth becomes more habitable. It gives ways of travel to the poor that the rich of old did not dream of. It floods the night hours with light. It takes the brutal part away from human labor. It is creative. The Engineer is co-partner with the gods and the master of gravitation.

TWO KINDS OF EDUCATION FOR ENGINEERS.

By

Dean J. B. Johnson.

The following masterly treatment of the subject of certain phases of engineering education is by the late Prof. J. B. Johnson, a technical instructor and author of the highest rank. In his early death, which was accidental, the engineering profession in America suffered a severe loss that is felt to this day.

Prof. Johnson was a deep, clear thinker and a technical writer of wide scope and great vigor. His English, as exemplified in the following address, may well serve as a model to engineering students, and the advice that he gave is of the soundest.

This paper will bear several close perusals.

John Butler Johnson was born near Marlboro, Stark County, Ohio, June 11, 1850. He attended school at Marlboro until sixteen years of age; and from 1868 till 1872 he taught school in Indiana and Arkansas, then went to Indianapolis as Secretary of the School Board. He also taught for one year in the Indianapolis High School.

In 1874 he entered the University of Michigan, where he was graduated in 1878 from the Civil Engineering Department. From 1878 to 1881 he was engaged on a survey of the Great Lakes; and from 1881 to 1883 he was Assistant Engineer to the Mississippi River Commission.

In 1883 he was elected to the chair of Civil Engineering in Washington University at St. Louis, where he remained until called to be Dean of the Engineering School of the University of Wisconsin in January, 1899, which latter position he held when he met his untimely death on June 23, 1902.

He was a member of the principal engineering societies of America and England and the author of numerous important papers and books on engineering subjects. Some of the latter are still used as text books in a number of the leading technical schools and universities of America.

Prof. Johnson's entire career as a man, an enigneer, an instructor, and a technical writer was ideal; and it may well serve as a model to future generations of young engineers.

Editors.

TWO KINDS OF EDUCATION FOR ENGINEERS.

By

Professor J. B. Johnson.

Education may be defined as a means of gradual emancipation from the thraldom of incompetence. Since incompetence leads of necessity to failure, and since competence alone leads to certain success, in any line of human endeavor, and since the natural or uneducated man is but incompetence personified, it is of supreme importance that this thraldom, or this enslaved condition in which we are all born, should be removed in some way. While unaided individual effort has worked, and will continue to work marvels, in rare instances in our so-called self-made men, these recognized exceptions acknowledge the rule that mankind in general must be aided in acquiring this complete mastery over the latent powers of head, heart, and hand. These formal aids in this process of emancipation are found in the grades of schools and colleges with which the children of this country are now blessed beyond those of almost any other country or time. The boys or girls who fail to embrace these emancipating opportunities to the fullest extent practicable, are thereby consenting to degrees of incompetence and their corresponding and resulting failures in life, which they have had it in their power to prevent. This they will ultimately discover to their chagrin and even grief, when it is too late to regain the lost opportunities.

There are, however, two general classes of competency which I wish to discuss to-day, and which are generated in the schools. These are, *Competency to Serve,* and *Competency to Appreciate and Enjoy.*

By competency to serve is meant that ability to perform one's due proportion of the world's work which brings to society a common benefit, which makes of this world a continually better home for the race; and which tends to fit the race for that immortal life in which it puts its trust.

By competency to appreciate and enjoy is meant that ability to understand, to appropriate, and to assimilate those great personal achievements of the past and present in the fields of the true, the beautiful, and the good, which brings into our lives a kind of peace, and joy, and gratitude which can be found in no other way.

It is true that all kinds of elementary education contribute alike to both of these ends, but in the so-called higher education it is too common to choose between them rather than to include them both. Since it is only service which the world is willing to pay for, it is

only those competent and willing to serve a public or private utility who are compensated in a financial way. It is the education which brings a competency to serve, therefore, which is often called the utilitarian, and sometimes spoken of contemptuously as the bread-and-butter education. On the other hand the education which gives a competency to appreciate and to enjoy is commonly spoken of as a cultured education. As to which kind of education is the higher and nobler, if they must be contrasted, it all depends on the point of view. If personal pleasure and happiness are the chief end and aim in life, then for that class of persons who have no disposition to serve, the cultural education is the more worthy of admiration and selection (conditioned of course on the bodily comforts being so far provided for as to make all financial compensations of no object to the individual). If, however, service to others is the most worthy purpose in life, and if in addition such service brings the greatest happiness, then that education which develops the ability to serve, in some capacity, should be regarded as the higher and more worthy. This kind of education has the further advantage that the money consideration it brings makes its possessor a self-supporting member of society instead of a drone or parasite, which those people must be who can not serve. I never could see the force of the statement that "they also serve who only stand and wait." It is possible they may serve their own pleasures, but if this is all, the statement should be so qualified.

The higher education which leads to a life of service has been known as a professional education, as law, medicine, the ministry, teaching, and the like. These have long been known as the learned professions. A learned profession may be defined as a vocation in which scholarly accomplishments are used in the service of society or of other individuals, for a valuable consideration. Under such a definition every new vocation in which a very considerable amount of scholarship is required for its successful prosecution, and which is placed in the service of others, must be held as a learned profession. And as engineering now demands fully as great an amount of learning, or scholarship, as any other, it has already taken a high rank among these professions, although as a learned profession it is scarcely half a century old. Engineering differs from all other learned professions, however, in this, that its learning has to do only with the inanimate world, the world of dead matter and force. The materials, the laws, and the forces of nature, and scarcely to any extent its life, are the peculiar field of the engineer. Not only is the engineer pretty thoroughly divorced from life in general, but even with that society of which he is a part his professional life has little in common.

His profession is so new it practically has no past, either of history or of literature, which merits his consideration, much less his laborious study. Neither do the ordinary social or political problems enter in any way into his sphere of operations. Natural law, dead matter, and lifeless force make up his working world, and in these he lives and moves and has his professional being. Professionally regarded, what to him is the history of his own or of other races? What have the languages and the literatures of the world of value to him? What interest has he in domestic or foreign politics, or in the various social and religious problems of the day? In short what interest is there for him in what we now commonly include in the term "the humanities"? It must be confessed that in a professional way they have little or none. Except perhaps two other modern languages by which he obtains access to the current progress in applied science, he has practically no professional interest in any of these things. His structures are made no safer or more economical; his prime-movers are no more powerful or efficient; his electrical wonders no more occult or useful; his tools no more ingenious or effective, because of a knowledge of all these humanistic affairs. As a mere server of society, therefore, an engineer is about as good a tool without all this cultural knowledge as with it. But as a citizen, as a husband and father, as a companion, and more than all, as one's own constant, perpetual, unavoidable personality, the taking into one's life of a large knowledge of the life and thought of the world, both past and present, is a very important matter indeed, and of these two kinds of education, as they affect the life-work, the professional success, and the personal happiness of the engineer, I will speak more in detail.

I am here using the term engineer as including that large class of modern industrial workers who make the new application of science to the needs of modern life their peculiar business and profession. A man of this class may also be called an applied scientist. Evidently he must have a large acquaintance with such practical sciences as surveying, physics, chemistry, geology, metallurgy, electricity, applied mechanics, kinematics, machine design, power generation and transmission, structural designing, land and water transportation, etc., etc. And as a common solvent of all the problems arising in these various subjects he must have acquired an extended knowledge of mathematics, without which he would be like a sailor with neither compass nor rudder. To the engineer mathematics is a tool of investigation, a means to an end, and not the end itself. The same may be said of his physics, his chemistry, and of all his

other scientific studies. They are all to be made tributary to the solution of problems which may arise in his professional career. His entire technical education, in fact, is presumably of the useful character, and acquired for specific useful ends. Similarly he needs a free and correct use of his mother tongue, that he may express himself clearly and forcibly both in speech and composition, and an ability to read both French and German, that he may read the current technical literature in the two other languages which are most fruitful in new and original technical matter.

It is quite true that the mental development, the growth of one's mental powers and the command over the same, which comes incidentally in the acquisition of all this technical knowledge, is of far more value than the knowledge itself, and hence great care is given in all good technical schools to the mental processes of the students, and to a thorough and logical method of presentation and of acquisition. In other words, while you are under our instruction it is much more important that you should think consecutively, rationally, and logically, than that your conclusions should be numerically correct. But as soon as you leave the school the exact reverse will hold. Your employer is not concerned with your mental development, or with your mental processes, so long as your results are correct, and hence we must pay some attention to numerical accuracy in the school, especially in the upper classes. We must remember, however, that the mind of the engineer is primarily a workshop and not a warehouse or lumber-room of mere information. Your facts are better stored in your library. Room there is not so valuable as it is in the mind, and the information, furthermore, is better preserved. Memory is as poor a reliance to the engineer as to the accountant. Both alike should consult their books when they want the exact facts. Knowledge alone is not power. The ability to use knowledge is a latent power, and the actual use of it is a power. Instead of storing your minds with useful knowledge, therefore, I will say to you, store your minds with useful tools, and with a knowledge only of how to use such tools. Then your minds will become mental workshops, well fitted for turning out products of untold value to your day and generation. Everything you acquire in your course in this college, therefore, you should look upon as mental tools with which you are equipping yourselves for your future careers. It may well be that some of your work will be useful rather for the sharpening of your wits and for the development of mental grasp, just as gymnastic exercise is of use only in developing your physical system. In this case it has served as a tool of development instead of one for subse-

quent use. Because all your knowledge here gained is to serve you as tools it must be acquired quantitatively rather than qualitatively. First, last, and all the time, you are required to know not how simply, but how much, how far, how fast, to what extent, at what cost, with what certainty, and with what factor of safety. In the cultural education where one is learning only to appreciate and to enjoy, it may satisfy the average mind to know that coal burned under a boiler generates steam which entering a cylinder moves a piston which turns the engine, and stop with that. But the engineer must know how many heat units there are in a pound of coal burned, how many of these are generated in the furnace, how many of them pass into the water, how much steam is consumed by the engine per horsepower per hour, and finally how much effective work is done by the engine per pound of coal fed to the furnace. Merely qualitative knowledge leads to the grossest errors of judgment and is of that kind of little learning which is a dangerous thing. At my summer home I have a hydraulic ram set below a dam, for furnishing a water supply. Nearby is an old abandoned water-power grist mill. A man and his wife were looking at the ram last summer and the lady was overheard to ask what it was for. The man looked about, saw the idle water-wheel of the old mill, and ventured the opinion that it must be used to run the mill! He knew a hydraulic ram when he saw it and he knew it was used to generate power, and that power would run a mill. *Ergo,* a hydraulic ram will run a mill. This is on a par with thousands of similar errors of judgment where one's knowledge is qualitative only. All engineering problems are purely quantitative from the beginning to the end, and so are all other problems, in fact, whether material, or moral, or financial, or commercial, or social, or political, or religious. All judgments passed on such problems, therefore, must be quantitative judgments. How poorly prepared to pass such judgments are those whose knowledge is qualitative only! Success in all fields depends very largely on the accuracy of one's judgment in foreseeing events, and in engineering it depends wholly on such accuracy. An engineer must see all around his problems, and take account of every contingency which can happen in the ordinary course of events. When all such contingencies have been foreseen and provided against, then the unexpected cannot happen, as everything has been foreseen. It is customary to say, "The unexpected always happens." This of course is untrue. What is meant is "It is only the unexpected which happens," for the very good reason that what has been anticipated has been provided against.

In order that knowledge may be used as a tool in investigations

and in the solution of problems, it must be so used constantly during the period of its acquisition. Hence the large amount of drawing-room, field, laboratory, and shop practice introduced into our engineering courses. We try to make theory and practice go hand in hand. In fact we teach that theory is only generalized practice. From the necessary facts, observed in special experiments or in actual practice, and which cover a sufficiently wide range of conditions, general principles are deduced from which effects of given like causes can be foreseen or derived, for new cases arising in practice. This is like saying, in surveying, that with a true and accurate hind-sight an equally true and accurate forward course can be run. Nearly all engineering knowledge, outside the pure mathematics, is of this experimental or empirical character, and we generally know who made the experiments, under what conditions, over what range of varying conditions, how accordant his results were, and hence what weight can be given to his conclusions. When we can find in our engineering literature no sufficiently accurate data, or none exactly covering the case in hand, we must set to work to make a set of experiments which will cover the given conditions, so as to obtain numerical factors, or possibly new laws, which will serve to make our calculations prove true in the completed structure or scheme. The ability to plan and carry out such crucial tests and experiments is one of the most important objects of an engineering college training, and we give our students a large amount of such laboratory practice. In all such work it is the absolute truth we are seeking and hence any guessing at data or falsifying of records, or "doctoring" of the computations is of the nature of a professional crime. Any copying of records from other observers, when students are supposed to make their own observations, is both a fraud upon themselves as well as dishonest to their instructor, and indicates a disposition of mind which has nothing in common with that of the engineer, who is always and everywhere a truth-seeker and truth-tester. The sooner such a person leaves the college of engineering the better for him and for the engineering profession. Men in other professions may blunder or play false with more or less impunity. Thus the lawyer may advocate a bad cause without losing caste; a physician may blunder at will, but his mistakes are soon buried out of sight; a minister may advocate what he no longer believes himself, and feel that the cause justifies his course; but the mistakes of the engineer are quick to find him out and to proclaim aloud his incompetence. He is the one professional man who is obliged to be right, and for whom sophistry and self-deception are a fatal poison. But the en-

gineer must be more than honest, he must be able to discern the truth. With him an honest motive is no justification. He must not only *believe* he is right; he must *know* he is right. And it is one of the greatest elements of satisfaction in this profession, that it is commonly possible to secure in advance this almost absolute certainty of results. We deal with fixed laws and forces, and only so far as the materials used may be faulty, or of unknown character, or as contingencies could not be foreseen or anticipated, does a necessary ignorance enter into the problem.

It must not be understood, however, that with all of both the theory and practice we are able to give our students in their four or five-year course, they will be full-fledged engineers when they leave us. They ought to be excellent material out of which, with a few years' actual practice, they would become engineers of the first order. Just as a young physician must have experience with actual patients, and as a young lawyer must have actual experience in the courts, so must an engineer have experience with real problems before he can rightfully lay claim to the title of engineer. And in seeking this professional practice they must not be too choice. As a rule the higher up one begins the sooner his promotion stops, and the lower down he begins the higher will he ultimately climb. The man at the top should know in a practical way all the work over which he is called upon to preside, and this means beginning at the bottom. Too many of our graduates refuse to do this, and so they stop in a middle position, instead of coming into the management of the business, which position is reserved for a man who knows it all from the bottom up. Please understand that no position is too menial in the learning of a business. But as your college training has enabled you to learn a new thing rapidly, you should rapidly master these minor details of any business, and in a few years you should be far ahead of the ordinary apprentice who went to work from the grammar school or from the high school. The great opportunity for the engineer of the future is in the direction and management of our various manufacturing industries. We are about to become the world's workshop, and as competition grows sharper and as greater economies become necessary, the technically trained man will become an absolute necessity in the leading positions in all our industrial works. These are the positions hitherto held by men who have grown up with the business, but without technical training. They are being rapidly supplanted by technical men, who, however, must serve their apprenticeship in the business, from the bottom up. With this combination of theory and practice, and with the American genius for invention,

and with our superb spirit of initiative and of independence, we are already setting a pace industrially which no other nation can keep, and which will soon leave all others hopelessly behind.

In the foregoing description of the technical education and work of the engineer, the engineer himself has been considered as a kind of human tool to be used in the interest of society. His service to society alone has been in contemplation. But as the engineer has also a personality which is capable of appreciation and enjoyment of the best this world has produced in the way of literature and art; as he is to be a citizen and a man of family; and moreover, since he has a conscious self with which he must always commune and from which he cannot escape, it is well worth his while to see to it that this self, this husband and father, this citizen and neighbor, is something more than a tool to be worked in other men's interests, and that his mind shall contain a library, a parlor, and a drawing-room, as well as a work-shop. And yet how many engineers' minds are all shops and out of which only shop-talk can be drawn! Such men are little more than animated tools, worked in the interest of society. They are liable to be something of a bore to their families and friends, almost a cipher in the social and religious life of the community, and a weariness to the flesh to their more liberal minded professional brethren. Their lives are one continuous grind, which has for them doubtless a certain grim satisfaction, but which is monotonous and tedious in comparison with what they might have been. Even when valued by the low standard of money-making, they are not nearly so likely to secure lucrative incomes as they would be with a greater breadth of information and worldly interest. They are likely to stop in snug professional berths which they find ready-made for them, under some sort of fixed administration, and maintain through life a subordinate relation to directing heads who, with a tithe of their technical ability, are yet able, with their worldly knowledge, their breadth of interests, and their fellowship with men, to dictate to these narrower technical subordinates, and to fix for them their fields of operation.

In order, therefore, that the technical man, who in material things knows what to do and how to do it, may be able to get the thing done and to direct the doing of it, he must be an engineer of men and of capital as well as of the materials and forces of nature. In other words he must cultivate human interests, human learning, human associations, and avail himself of every opportunity to further these personal and business relations. If he can make himself a good business man, or as good a manager of men, as he usually makes of

himself in the field of engineering he has chosen, there is no place too great, and no salary too high for him to aspire to. Of such men are our greatest railroad presidents and general managers and the directors of our largest industrial establishments. While most of this kind of knowledge must also be acquired in actual practice, yet some of it can best be obtained in college. I shall continue to urge upon all young men who can afford it either to take the combined six-year college and engineering course, described in our catalogue, or the five-year course in the College of Engineering, taking as extra studies many things now taught in our School of Commerce. The one crying weakness of our engineering graduates is ignorance of the business, the social, and the political world, and of human interests in general. They have little knowledge in common with the graduates of our literary colleges, and hence often find little pleasure in such associations. They become clannish, run mostly with men of their class, take little interest in the commercial or business departments of the establishments with which they are connected, and so become more and more fixed in their inanimate worlds of matter and force. I beseech you, therefore, while yet students, to try to broaden your interests, extend your horizons now into other fields, even but for a bird's-eye view, and profit, so far as possible, by the atmosphere of universal knowledge which you can breathe here through the entire period of your college course. Try to find a chum who is in another department; go to literary societies; haunt the library; attend the available lectures in literature, science, and art, attend the meetings of the Science Club; and in every way possible, with a peep here and a word there, improve to the utmost these marvelous opportunities which will never come to you again. Think not of tasks; call no assignments by such a name. Call them opportunities, and cultivate a hunger and thirst for all kinds of humanistic knowledge outside your particular world of dead matter, for you will never again have such an opportunity, and you will be always thankful that you made good use of this, your one chance in a lifetime.

For your own personal happiness, and that of your immediate associates, secure in some way, either in college or after leaving the same, an acquaintance with the world's best literature, with the leading facts of history, and with the biographies of many of the greatest men in pure and applied science, as well as of statesmen and leaders in many fields. With this knowledge of great men, great thoughts, and great deeds, will come that lively interest in men and affairs which is held by educated men generally, and which will put you on an even footing with them in your daily intercourse. This kind of

knowledge also elevates and sweetens the intellectual life, leads to the formation of lofty ideals, helps one to a command of good English, and in a hundred ways refines, and inspires to high and noble endeavor. This is the cultural education leading to that appreciation and enjoyment man is assumed to possess.

Think not, however, that I depreciate the peculiar work of the engineering college. It is by this kind of education alone that America has already become supreme in nearly all lines of material advancement. I am only anxious that the men who have made these things possible shall reap their full share of the benefits.

In conclusion let me congratulate you on having selected courses of study which will bring you into the most intimate relations with the world's work of your generation. All life to-day is one endless round of scientific applications of means to ends, but such applications are still in their infancy. A decade now sees more material progress than a century did in the past. Not to be scientifically trained in these matters is equivalent to-day to a practical exclusion from all part and share in the industrial world. The entire direction of the world's industry and commerce is to be in your hands. You are also charged with making the innumerable new discoveries and inventions which will come in your generation and almost wholly through men of your class. The day of the inventor, ignorant of science and of nature's laws, has gone by. The mere mechanical contrivances have been pretty well exhausted. Henceforth profitable invention must include the use or embodiment of scientific principles with which the untrained artisan is unacquainted. More and more will invention be but the scientific application of means to ends, and this is what we teach in the engineering schools. Already our patent office is much puzzled to distinguish between engineering and invention. Since engineering proper consists in the solution of new problems in the material world, and invention is likewise the discovery of new ways of doing things, they cover the same field. But an invention is patentable, while an engineering solution is not. Invention is supposed in law to be an inborn faculty by which new truth is conceived by no definable way of approach. If it had not been reached by this particular individual, it is assumed that it might never have been known. An engineering solution is supposed, and rightly, to have been reached by logical processes through known laws of matter, and force, and motion, so that another engineer, given the same problem, would probably have reached the same or an equivalent result. And this is not patentable. Already a very large proportion of the patents issued could be nullified on this ground, if the attorneys only knew enough

to make their case. More and more, therefore, are the men of your class to be charged with the responsibility and to be credited with the honor of the world's progress, and more and more is the world's work to be placed under your direction. The world will be remade by every succeeding generation, and all by the technically educated class. These are your responsibilities and your honors. The tasks are great and great will be your rewards. That you may fitly prepare yourself for them is the hope and trust of your teachers in this college of engineering.

I will close this address by quoting Professor Huxley's definition of a liberal education. Says Huxley: "That man, I think, has had a liberal education who has been so trained in youth that his body is the ready servant of his will, and does with ease and pleasure all the work that, as a mechanism, it is capable of; whose intellect is a clear, cold, logic-engine, with all its parts of equal strength, and in smooth working order; ready, like a steam engine, to be turned to any kind of work, and spin the gossamers as well as forge the anchors of the mind; whose mind is stored with a knowledge of the great and fundamental truths of Nature and of the laws of her operations; one who, no stunted ascetic, is full of life and fire, but whose passions are trained to come to heel by a vigorous will, the servant of a tender conscience; who has learned to love all beauty, whether of nature or of art, to hate all vileness, and to respect others as himself.

"Such a one and no other, I conceive, has had a liberal education; for he is, as completely as a man can be, in harmony with Nature. He will make the best of her, and she of him. They will get on together rarely; she as his ever beneficient mother; he as her mouthpiece, her conscious self, her minister and interpreter."

THE DURABLE SATISFACTIONS OF LIFE.

By

Dr. Charles W. Eliot.

Dr. Eliot, who for many years was President of Harvard University, treats in this paper of matters of prime importance to all young men who desire sound education; hence it should be read with care and attention by engineering students. The principle of *mens sana in corpore sano* is one that was long ago established; but, unfortunately, it is still too often ignored, especially in student life. Young men are prone to go to either one extreme or the other; and, especially in engineering schools, earnest students are given to developing the mind at the expense of the body. This is a practice which cannot be too forcibly condemned; for, (to misquote holy writ) "what profiteth a man if he gain the whole of knowledge and lose his own body?"

Dr. Eliot's remarks concerning "trained capacity for mental labor" are words of wisdom and should be heeded, and what he says about honor and reputation should be the very gospel of engineering students.

It is through the courtesy of Messrs. Thomas Y. Crowell and Company, Publishers, that permission has been obtained to reproduce this paper from their book entitled "Durable Satisfactions of Life" by Charles W. Eliot.

Dr. Eliot's biographical record is as follows:

He was born in Boston, Massachusetts, March 20, 1834, and was fitted for college at the Boston Latin School. He graduated from Harvard in 1853 with the degree of A. B., and in 1857 took there his A. M. He has received the degree of LL. D. from the following institutions: Williams and Princeton in 1869, Yale in 1870, Johns Hopkins in 1902, and Tulane, Missouri, and Harvard in 1900.

From 1854 to 1858 he was Tutor in Mathematics at Harvard, and at the same time a student in chemistry under Professor Josiah P. Cooke; from 1858 to 1863 he was Assistant Professor of Mathematics and Chemistry in Lawrence Scientific School (Harvard); from 1863 to 1865 he studied chemistry and investigated educational methods in Europe; from 1865 to 1869 he was Professor of Analytical Chemistry in Massachu-

setts Institute of Technology, spending a portion of 1867 and 1868 in France; from 1869 to 1909 he was President of Harvard University; and since 1909 he has been President Emeritus thereof.

He is an Officer of the Legion of Honor of France, has received the First-Class Order of the Rising Sun of Japan and the First-Class Royal Prussian Order of the Crown, and is a Grand Officer of the Crown of Italy.

He is a Corresponding Member of the Academy of Moral and Political Sciences of *L' Institut de France,* Fellow of the American Academy of Arts and Sciences, Member of the Massachusetts Historical Society and of the American Philosophical Society, and Honorary President of the National Conservation Association.

He has delivered many noteworthy addresses on educational and scientific matters, and is the author of several standard books on chemistry and other subjects—scientific, educational, and humanitarian.

Editors.

THE DURABLE SATISFACTIONS OF LIFE.

By

Dr. Charles W. Eliot.

For educated men what are the sources of the solid and durable satisfactions of life? I hope you are all aiming at the solid, durable satisfactions of life, not primarily the gratifications of this moment or of to-morrow, but the satisfactions that are going to last and grow. So far as I have seen, there is one indispensable foundation for the satisfactions, of life—health. A young man ought to be a clean wholesome, vigorous animal. That is the foundation for everything else, and I hope you will all be that, if you are nothing more. We have to build everything in this world of domestic joy and professional success, everything of a useful, honorable career, on bodily wholesomeness and vitality.

This being a clean, wholesome, vigorous animal involves a good deal. It involves not condescending to the ordinary barbaric vices. One must avoid drunkenness, gluttony, licentiousness, and getting into dirt of any kind, in order to be a clean, wholesome, vigorous animal. Still, none of you would be content with this achievement as the total outcome of your lives. It is a happy thing to have in youth what are called animal spirits—a very descriptive phrase; but animal spirits do not last even in animals; they belong to the kitten or puppy stage. It is a wholesome thing to enjoy for a time, or for a time each day all through life, sports and active bodily exercise. These are legitimate enjoyments, but if made the main object of life, they tire. They cease to be a source of durable satisfaction. Play must be incidental in a satisfactory life.

What is the next thing, then, that we want in order to make sure of durable satisfaction in life? We need a strong mental grip, a wholesome capacity for hard work. It is intellectual power and aims that we need. In all the professions—learned, scientific, or industrial—large mental enjoyments should come to educated men. The great distinction between the privileged class to which you belong, the class that has opportunity for prolonged education, and the much larger class that has not that opportunity, is that the educated class lives mainly by the exercise of intellectual powers and gets, therefore, much greater enjoyment out of life than the much larger class

that earns a livelihood chiefly by the exercise of bodily powers. You ought to obtain here, therefore, the trained capacity for mental labor, rapid, intense, and sustained. That is the great thing to get in college, long before the professional school is entered. Get it now. Get it in the years of college life. It is the main achievement of college life to win this mental force, this capacity for keen observation, just inference, and sustained thought, for everything that we mean by the reasoning power of man. That capacity will be the main source of intellectual joys and of happiness and content throughout a long and busy life.

But there is something more, something beyond this acquired power of intellectual labor. As Shakespeare puts it, "the purest treasure mortal times afford is spotless reputation." How is that treasure won? It comes by living with honor, on honor. Most of you have begun already to live honorably and honored, for the life of honor begins early. Some things the honorable man cannot do, never does. He never wrongs or degrades a woman. He never oppresses or cheats a person weaker or poorer than himself. He never betrays a trust. He is honest, sincere, candid, and generous. It is not enough to be honest. An honorable man must be generous, and I do not mean generous with money only. I mean generous in his judgments of men and women, and of the nature and prospects of mankind. Such generosity is a beautiful attribute of the man of honor.

How does honor come to a man? What is the evidence of the honorable life? What is the tribunal which declares at last, "This was an honorable man"? You look now for the favorable judgment of your elders,—of parents and teachers and older students; but these elders will not be your final judges, and you had better get ready now in college to appear before the ultimate tribunal, the tribunal of your contemporaries and the younger generations. It is the judgment of your contemporaries that is most important to you; and you will find that the judgment of your contemporaries is made up alarmingly early,—it may be made up this year in a way that sometimes lasts for life and beyond. It is made up in part by persons to whom you have never spoken, by persons who in your view do not know you, and who get only a general impression of you; but always it is contemporaries whose judgment is formidable and unavoidable. Live now in the fear of that tribunal,—not an abject fear, because independence is an indispensable quality in the honorable man. There is an admirable phrase in the Declaration of Independence, a document which it was the good fashion of my time for boys to commit to

memory. I doubt if that fashion still obtains. Some of our public action looks as if it did not. "When, in the course of human events, it becomes necessary for one people to dissolve the political bands which have connected them with another, and to assume among the powers of the earth the separate and equal station to which the laws of nature and of nature's God entitle them, a decent respect to the opinions of mankind requires that they should declare the causes which impel them to the separation." That phrase—"a decent respect"—is a very happy one. Cherish "a decent respect to the opinions of mankind," but never let that interfere with your personal declaration of independence. Begin now to prepare for the judgment of the ultimate human tribunal.

Look forward to the important crises of your life. They are nearer than you are apt to imagine. It is a very safe protective rule to live to-day as if you were going to marry a pure woman within a month. That rule you will find a safeguard for worthy living. It is a good rule to endeavor hour by hour and week after week to learn to work hard. It is not well to take four minutes to do what you can accomplish in three. It is not well to take four years to do what you can perfectly accomplish in three. It is well to learn to work intensely. You will hear a good deal of advice about letting your soul grow and breathing in without effort the atmosphere of a learned society or place of learning. Well, you cannot help breathing and you cannot help growing; those processes will take care of themselves. The question for you from day to day is how to learn to work to advantage, and college is the place and now is the time to win mental power. And, lastly, live to-day and every day like a man of honor.

ENGINEERING EDUCATION.

By

Professor Frank P. McKibben.

This paper, which contains in condensed form much valuable advice to engineering students, is reprinted from an editorial written for the Engineering Record; consequently the doctrine that it preaches may be considered to have the official endorsement of that high authority.

The author graduated from the Massachusetts Institute of Technology in 1894, and began immediately teaching there, rising rapidly through the grades of Assistant Instructor, Instructor, Assistant Professor, and Associate Professor. In 1907 he was called to Lehigh University to take the chair of Civil Engineering, which position he still holds. Professor McKibben, however, is no mere theorist; for while attending carefully to his pedagogical work, he has simultaneously therewith filled the following positions:

1897-1898; Assistant Engineer on the New Bedford, Mass., bridge.

1899-1901; Assistant Engineer to the Boston Elevated Railway Co., Boston, Mass.

1901-1907; Assistant Engineer to the Massachusetts Railroad Commission, Boston, Mass.

In addition to the preceding, he was Librarian of the Boston Society of Civil Engineers from 1902 to 1907.

He is a member of the American Society of Civil Engineers, the American Society for Testing Materials, the Engineers' Society of Pennsylvania, and the Society for the Promotion of Engineering Education.

Editors.

ENGINEERING EDUCATION.

By

Professor Frank P. McKibben.

Now that the time has arrived for engineering students to return to their respective universities and technical schools, it is appropriate for them, before beginning the year's work, to survey the field with a view of deriving the greatest benefit from the time and money spent in the undertaking; in other words, to see the purpose of an engineering education. The object which every young man should have for securing an education of any kind is to learn how to live, which includes a great deal more than the mere process of "making a living." The student who spends four years at a school with this firmly fixed in his mind will derive vastly more benefit than the one who thinks of his course as simply a means of "getting a job" upon graduation. He must remember that, to secure the greatest development, it is necessary to grow morally, mentally, and physically; and if he neglects any one of these elements he has not made the most of his opportunities. Students as a rule allow themselves to be too easily influenced by what is customary rather than by what is best. For example, many spend no time in out-of-door sports except to watch the weekly 'varsity contest, which is proper as far as it goes, but which is not so effective in building up a strong body as is a daily game of tennis or other similar healthy exercise. Throughout the entire course some form of legitimate physical exercise should be indulged in, with a view of improving the body rather than with a determination of breaking an intercollegiate record, which in the breaking is very apt to overtax the powers of him who attempts it.

Next to developing a strong body the student should exert his best efforts to accomplishing two things. First, he should train himself to understand and to deal with his fellow students and the teaching corps, and to make as many friends as possible in both these bodies. If this quality of mixing with men can be acquired in college, it will not only render college days more pleasant and more profitable, but it will result in a breadth of view about men and things that will make the student a more useful citizen throughout his after life. To accomplish this it is necessary, among other things, to take part in some of the various social activities which are to be found in every school, but here again a middle course must be taken and the student must not become entangled in so many of these non-scholastic activities as to allow them to

absorb his attention to the extent that other features of his training are neglected. In other words, it must not be forgotten that there are several things to be gotten out of college, and no student should so specialize in the social activities as to be found wanting either in the physical or scholastic training.

While engaged in strengthening the physical and social sides, social here being used in its broad sense, each student must constantly bear in mind that the training of his mental faculties is one of the principal objects of his being in college; that while he is engaged in acquiring knowledge of engineering principles he should realize that this is a matter of the greatest importance and that whether he is in the class room, in the laboratory, or on the athletic field, his studies should be considered a serious part of his life's work. Although the mental training has here been considered last it must not be assumed that it is of minor importance, for the three sides of his development are of equal value both to the young man himself and to the world at large.

It is essential that the function of the engineering course should be clearly understood and kept in mind by students and instructors. These courses should be followed in such a way that the student will not only learn how to think, but how to accomplish things as well, for the world gauges a man not only by what he knows, but also by what he does and the manner in which he does it. The power to formulate and to solve new questions which are constantly arising in industrial, in engineering, and in scientific fields is what each man should strive to obtain. To this end he must acquire methods of clear thinking, habits of industry, accuracy, and reliability. Let not the standard be the quality of work that will secure the lowest passing mark, but rather let it be of a quality which creates the self-satisfaction coming from having done one's best work. In other words, no man should be satisfied until he has done the best that he is capable of doing, and he must remember that it is vastly more important to himself that he sets and maintains a high standard in his work than it is for the teacher, or later his employer, to set it for him.

Few students realize the value of being accurate. Unfortunately, this is not altogether the student's fault, because it is the custom in most engineering schools to give more work than students can do well, and then to be satisfied if they do 60 per cent. of it. The 60 per cent. represents the usual passing grade. Under this system it is difficult for a young man to do his best, but he should strive to eliminate errors by being constantly on guard against them. Let it not be forgotten that it is results, accurate and reliable, that are wanted; that to understand the principles involved and to make numerous arithmetical or other mistakes in their application is even more serious than not to have

the principles at all. In this connection it is desirable to emphasize the importance of self-training. The very best teacher can only point out the way, and it is for the student then to assume the responsibility of following it. Each man should cultivate self-reliance, and should closely scrutinize his own work in order that mistakes may be finally reduced to a minimum. This question of exercising care is a very serious one, and cannot be too strongly impressed upon teachers and students in our engineering schools.

A thorough understanding of the underlying principles of chemistry, mathematics, and physics is very necessary in engineering, and the engineering school is by far the best place to get it. In addition to these subjects it is essential that attention be paid to their application, as exemplified in the study of hydraulics, strength of materials, and various forms of design, such as bridge and machine design. Design is especially useful because it trains the imagination, encourages resourcefulness, develops ability to attack and solve new problems, and what is of paramount importance, it fixes the principles as no other method of instruction can. By design is meant the application of principles of mechanics to determining the size and strength of the various parts of a structure without going so far into the details as to lose sight of the main problem. Let no one be deceived by thinking that he is learning bridge engineering when he is really memorizing the sizes of heads corresponding to certain commercial sizes of rivet shanks. Details such as this can be much better learned in the bridge company than in the college, while on the other hand, the principles of design can be more quickly, though no better, mastered in college.

All students of engineering should take part in the activities of their local engineering societies, and should be familiar with the principal technical journals, because after graduation they will find that their college courses will really be continued in a measure by preparing and reading papers before the national engineering societies and by contributing articles to the leading engineering periodicals. Furthermore, by reading a good engineering paper there is seen the result of the application of principles learned in the classrooms and the text-books, thus adding to the interest and enthusiasm of the college work. It is well, therefore, that while in college some knowledge be acquired of these two branches of what may be said to constitute the post-graduate course of the average engineer.

Finally, students should not attempt to specialize, but should get a broad, general training in fundamental principles, together with enough of their applications to fix them thoroughly. On the other hand, the mistake should not be made of confusing breadth with superficiality. A man can be broad and at the same time thorough.

THE VALUE OF ENGLISH TO THE TECHNICAL MAN.

By

John Lyle Harrington, Consulting Engineer.

Concerning the excellence or the reverse of this paper it behooveth not the Editors to speak, as it is the work of one of them; nevertheless it may, perhaps, legitimately be stated that after it was published in pamphlet form and widely distributed among engineers, professors, and students, it received unanimous approval and much commendation.

It was delivered early in 1907 to the Technological Society of Kansas City, the Engineering Society of the University of Missouri, and the Civil Engineering Society of the University of Kansas.

Upon whether its teachings be followed or ignored may depend the success or failure of any technical student to attain in after life the highest rank in the engineering profession. Possessing a mastery of the English language, he may or may not rise to eminence; but without it, he certainly cannot. Any engineering student who wilfully neglects the study of his own language deserves the failure to attain eminence which assuredly will be his fate.

Editors.

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Language is an instrument, a medium for the exchange of thought. If, in individual instances, both speaker and hearer employ words in the same sense and arrange them in the same manner, the expressed ideas will be perfectly understood, whether the language be in accordance with good usage or not. But, if thought is to be conveyed without loss to a larger audience, the medium must be substantially perfect. Words must not only be used in accordance with their accustomed and generally accepted meanings, and with all the shades and niceties of those meanings, but they must be arranged in accordance with the accepted construction of phrase, clause, and sentence; and the whole argument or thesis must be so ordered with regard to the sequence and the relations of the various ideas that the hearer shall be compelled to understand. Discourses in which thoughts, though they be ever so clearly expressed, are not arranged in logical order, will fail in their purpose, because the argument is confused and the mind of the hearer is occupied with the language instead of the substance of the thought. You will recall Sam Weller's remark regarding Mr. Nupkins' eloquence that "his ideas come out so fast they knock each other's heads off and you can't tell what he is driving at." Like any other instrument, the value of language is in direct proportion to our knowledge of it and our skill in its use. If we understand it fully and use it skillfully it will serve our purpose well, but if we are novices and bunglers, only disappointment will result.

Language, though it will not supply the place of thought, is a most essential instrument to every man. To him who is without important thought to express, it is not a very valuable tool. The laborer does not require it in handling the pick and shovel; it is only in his social relations that he has much need for speech. It is not important that the stoker speak fluently, or that the mechanic be an able orator or writer. But as we proceed from the lower to the higher and more intellectual occupations, the need and the value of knowledge and command of language rapidly increase. The politician, we sometimes think, makes skillful use of language to hide his thought, or to dissemble. Indeed, in all walks of life there are times when words are well employed to obscure the thought. But the physician must be

skillful in the use of language in order to direct and control his patients, as well as to write, and to understand the writings of his fellow physicians. The clergyman needs it to please, to inform, to convince, and to persuade his auditors. But the technical man, that is, the engineer, the architect, and the applied scientist of every kind, finds a sound, accurate knowledge of the language essential to him in every part of his work. A wide and precise knowledge of words is required in his reading as well as in his general writing; in his business and professional conversations even more than in those of a social nature. But, in the preparation and interpretation of technical correspondence, specifications, and contracts, the use of perfect language reaches the highest degree of importance. The lawyer alone needs to be so much of a precisian, and he attains that end by very awkward and cumbersome means.

The technical man of the highest order is not only a cultured gentleman, versed in all the amenities of polite society, familiar with the best literature in his own language and probably in that of one or two others, able to read many branches of learning understandingly and to discuss them intelligently; but, in addition, he has special knowledge of mathematics and the applied sciences, and he is not only able to understand what is written or spoken but can express his own thought regarding them readily, accurately, and logically. The successful technical man, it has been well said, must know much about everything and everything about something, but his ideas and knowledge are of small value except in so far as he can convey them to others; for, since he does not often labor with his hands, he must instruct and direct those who do. Thus, language is his most important tool, and it certainly behooves him to see that it is always in good order. His reputation as a gentleman and as a professional man depends very largely upon his knowledge and use of English.

Perfect English is impossible, for there is no absolute standard. Read any critical work on the language and you will find exhibited examples of faulty construction and of erroneous use of words taken from books by writers of the highest repute. Pope, a precisian himself, is frequently inaccurate. Johnson, whose chief work deals with the use of language, is bombastic in his writings, "makes little fishes talk like whales." Addison, whose English prose has long been considered the highest example of purity and elegance in style, is often grossly inaccurate, sometimes positively slovenly. But the English employed by writers of the highest rank, such as Milton, Goldsmith, Gibbon, Macaulay, Johnson, Hallam, Hume, Hawthorne, Motley, Irving, Prescott, Ruskin, and Stevenson, is the most perfect standard attainable. The usage of the best writers and speakers of the time is our highest

authority, but even usage is governed by precedent and reason. The language grows. New words are formed as they are needed; old ones become obsolete; current words acquire new meanings; and constructions change; consequently, no permanent standard can be set up, but usage must continue to change with the needs of English speaking people. One must speak the English of the present time, but the right use of the language demands conservatism, judgment, and taste in making additions or changes. Each new dictionary offered contains, according to the advertisements, a large number of words not to be found in any other. This seems to indicate rapid growth of the language, but, as a matter of fact, it has grown little since Shakespeare's day. The vaunted new words are largely gross barbarisms, entirely out of keeping with good usage, and consequently their life is short. The history of the language is of great value in determining what is correct usage, but reason and good taste are more perfect guides. No usage is good which is not in accord with them.

Bad English generally springs from ignorance or carelessness, quite as often from the one as from the other, but our newspaper-writers, and often our magazine-writers, are guilty of intentional abuse of the language. The newspapers reflect only the surface of life and rarely treat of substantial things; hence, they are, in the main, carelessly written; but they also deal largely in fine writing, employ large words and high sounding phrases in the discussion of simple matters, strive by exaggeration to excite wonder, and indulge freely in the use of slang. Their style is frequently, even commonly, bombastic and ridiculous, their matter stilted nonsense. This is especially true when engineering and other scientific matters are the subjects under discussion. Busy and sane men are provoked to find simple items of interest which might be fully stated in a few words expanded into long, tedious articles, filled with big, misused words; but the greater portion of the people read little else than the newspapers and seem to like the material they offer and the language they employ. When these facts are taken into consideration, it is remarkable that the newspaper's style is not in more general use; it is a matter for congratulation and speaks well for the common sense of the people that the newspapers have not caused greater corruption of the language.

The magazines are somewhat better in the English employed, but they are, as a rule, far below their professed standard. Hastily written stories, "pot-boilers" that are not worth reading, fill a large portion of their pages; and many of the cheaper magazines are well supplied with pretentiously written descriptions of engineering works and the discoveries and enterprises of applied chemistry. The maga-

zines, like the newspapers, cater to the popular demand for marvels by publishing ill-written, pseudo-scientific articles in which mole-hills always appear as mountains.

Our technical periodicals are decidedly better, for, though much of their matter is hastily and carelessly prepared and much of it gives abundant evidence of the writers' ignorance of the fundamental principles of the language, it is written in an honest spirit and is not padded or bombastic. Frequently the English is so crude, the thought so ill-expressed, that the matter fails to obtain, much less hold, the reader's attention. Long discussions appear in the columns which are open to correspondence, because terms are so carelessly employed that their import is not clear and disagreement results. It is not desirable that technical articles be elegantly or entertainingly written, but it is very important that their style be clear and concise and the diction accurate.

Some of the better magazines print only carefully selected matter and reject everything but scholarly, well written articles. Their influence upon the language is quite as good as that of the better books of the day; but the well written article costs more money than the "pot-boiler," hence, the magazine is more expensive, its circulation is limited, and it influences a smaller number of readers than does its cheap and less worthy competitor.

Periodical literature, if we may so designate the newspapers and magazines, has been thus discussed because it exerts enormous influence, much of it for evil, upon our language. Undoubtedly it has rendered large service in aiding the foreign-born part of our people to gain a working knowledge of the language quickly; and it has, probably more than any other agency, broken down any tendency toward the formation of sectional differences in the use of English, for while we hear more or less of the peculiarities of speech in the South and in New England, as a matter of fact the differences in the language of educated people are of small importance. Again, by no means all newspaper English is bad. Many journals are ably edited and publish leaders whose English is of the best, but the language employed in the body of substantially all newspapers abounds in gross errors.

The only influence which has greater sway over usage than periodical literature is the ordinary language of every day life. The language of childhood is exceedingly persistent. In fact some able writers on the subject go so far as to insist that one's English cannot be improved by study after maturity, that the usage of childhood will, with very slight modification, govern through life; but it seems hardly necessary to say that this view is extreme. If it were correct, the increasingly large amount of instruction in English given in our

high schools, colleges, and universities would be almost wholly wasted. To associate intimately with cultured people who speak good English, and to read well written books, are undoubtedly the easiest, most satisfactory, and most profitable methods of acquiring and retaining good usage; but it seems irrational to question the value of sound instruction in the fundamental laws of the language. It may be that by taking thought one cannot add one cubit to his stature, but by giving the matter close attention one can certainly improve one's use of the King's English. It is true that the influence of early habit is very strong. Men who have rooted out bad habits and acquired a good command of English, often, in moments of excitement, revert to the earlier usage, just as one who was foreign born will often revert to his mother tongue. But there is abundant reason to doubt that habits are ever so firmly fixed that they cannot be altered by exercising care. Our position would be rather hopeless if mental growth ceased at physical maturity. It is well known that the style of even our greatest writers improves with years.

Technical men are peculiarly prone to offend in the use of their mother tongue, because they have not, as a rule, read deeply in classical literature nor been instructed thoroughly in the construction of the language. Their higher education is generally almost entirely technical. Most of the engineering schools now require for matriculation substantially the same subjects that the colleges do, but some of the best still admit students with little more than a grammar school education, supplemented by the rudiments of the natural sciences and elementary mathematics. Cultural subjects are never required to any great extent, and they cannot be taught in the course. The curriculum is already well filled with scientific, mathematical, and technical subjects, and there is not room for a deep study of literature and the languages. The technical man who has a thorough knowledge of English has had the wisdom and patience to supplement his technical education by an arts course, has read widely of classic literature, or possesses the rare gift of language. Long continued and intimate association with those who employ excellent English will ensure reasonably good usage, in fact such association is almost essential, no matter what the education may be; but the knowledge of the language so acquired generally breaks down when it is applied to technical matters in which extreme accuracy is a requisite and in which the terms differ much from those used in ordinary conversation. There is no royal road to a knowledge of technical English.

Some of our better universities are now offering a six-years'

is sought. Deliberate elegance is a certain indication of pedantry and affectation and is often a sign of lack of breeding. Short words of English origin are invariably stronger and more rugged than their longer and more elegant synonyms which are derived from the Latin or Greek; hence their use is nearly always to be preferred except where the subject matter is abstruse or where nice distinctions in meaning are important. Then the Greek and Latin derivatives are frequently the more serviceable. But simplicity and force demand simple, direct language. The style should be so smooth and so unostentatious that the hearer's attention is not drawn to the language, but is left entirely free to follow the course of the thought.

It is deplorably rare to find young technical men in possession of an intimate knowledge of rhetoric. Business correspondence is often annoyingly protracted because one or both of the parties conducting it ignore the simple law of unity and fail to round out and complete the subject under discussion. Errors of style and gross errors of composition are quite as frequent in the correspondence of the technically educated man as they are in that of the ordinary clerk who went to work when he left the grammar school. It is because engineers are so little accustomed to order their thought and language properly that they have so little part in the business and correspondence of the corporations which employ them. It is notorious that a technist is rarely a good business man. This is partly because of the exaggerated importance he gives to technical matters, but very largely because his thought is clumsily expressed and awkwardly ordered.

The great value of the careful reading of good books lies very largely in the increased vocabulary and in the deeper knowledge of the nice distinctions in the meaning and the use of words. Two persons using the same dictionary will read definitions differently; and definitions are, at best, only the lexicographer's opinion as to what is the most general or most authoritative use of words. He records not only all the words he finds in use, good and bad alike, unless they are manifestly slang, but all the meanings of each, as well; and he does not attempt, except in a very general way, when he advises that a word is obsolete or colloquial, to instruct regarding usage. Good diction, however, cannot be acquired by reading alone. As words new to the vocabulary suggest themselves in the course of one's thought, great care must be taken to see that they are good words and that they are fully understood, for half knowledge is worse than ignorance. One has not made a word his own till he can use it correctly without thought or hesitation. The meanings of words vary widely and by nice differences, but ordinary lack of

energy to study and use the words which come into the mind is the chief cause of the poverty of language, which is often mistaken for poverty of thought. It is a common habit, when the meaning of a word which has suggested itself is not fully understood, to employ another which may imperfectly express the idea, but the meaning of which is known. Thus the vocabulary remains limited and inefficient through common laziness.

There are many gross faults of diction caused by ignorance or carelessness or both, such as the misuse of prepositions; the confusion of like and as and of lie and lay; the use of get to express possession, of grow for become; and the formation of verbs from nouns; but they are as nothing compared to the use of cant and slang.

Rigidity of ideas and poverty of language are chiefly responsible for cant, which is a fashion of using certain words in one legitimate sense to the exclusion of others, as though they possess a certain virtue which, because of this use, becomes peculiar to the user. It is closely akin to slang, but the words used are always genuine, and they are soberly and honestly employed. Its use is a certain indication of a lack of breadth and arouses a kind of contempt for the user in the minds of more liberal thinkers.

Slang consists of words, good and bad, and unmeaning jargon used in an arbitrary and conventional sense, generally with humorous purpose. But such humor is of the very cheapest kind, and it at once casts suspicion upon the entire discourse. Slang is rarely, if ever, permissible in writing, certainly not in business correspondence or in formal engineering documents; but, if good taste govern, it may occasionally be used with good effect in conversation. Slang that has come into general use is invariably vulgar. "Genteel" and "elegant" are mere crudities, but no one of good taste and breeding will employ "That's right," "Sure," "I don't think," "Nit," "Hully Gee," "Drive you to drink," and similar words and expressions, for they smack of the gutter.

Those who know the language so well that they use it correctly, yet unconsciously, may gain ease of expression by taking liberties with it in conversation; but the grosser errors in tense, person, and number are never permissible. Only the pedant will insist upon the use in conversation of the dignified language of formal literature; but liberty is not license; and pedantry is preferable to vulgarity.

A grammar which was once, and, for all I know, is still in general use states that "We think in words and when we lack fit words we lack fit thoughts." The statement sounds well and was generally accepted

without question by both teacher and scholar, but like many another plausible saying, it is only half true. When we lack fit words we certainly lack fit expression for our thought; but who has not sought urgently, even desperately, for a word to express the thought precisely and failed to find it. The sense of the idea was clear and persisted, but the word would not come. And how much thought does the Latin's shrug of the shoulders, the Jew's out-turned palms, or our own facial expression convey for which no word was ever formed, even in the mind. These expedients are employed to save language. They are suggestive, sometimes vague, but often exceedingly effective.. They, like the spoken word, are liable to misinterpretation; but they are none the less legitimate modes of expression.

One of my college professors used to say when he had mistaken my meaning that my thought was not properly expressed or he could not misunderstand it. If we all possessed a perfect knowledge of every detail of the language, if laws of construction and the meanings of words were absolutely fixed, this idea would be correct; but such a condition is impossible, and we shall go on misunderstanding each other till the end of time. But the more nearly we approach perfect knowledge of the language, the more nearly perfect a tool will it prove to be.

If words are well chosen and the construction is in accordance with good usage, it is very probable that the thought will be reasonably well conveyed, no matter what may be the character of the audience. At least we shall have done all that is possible by means of language to make ourselves understood; but as we depart from the ordinary small talk of every day life and deal with the unusual or abstruse subjects of philosophy, religion, or science, the terms become more uncommon and less generally known, the meaning is the more liable to be mistaken, and consequently, it is all the more essential that the best usage be carefully observed.

So far reaching are the effect of a difference in the meanings given to words or expressions that schools of philosophy which seem widely at variance often differ little except in the definitions of the fundamental terms employed. Many a heated argument, many a loss of temper and of friendship, many a suit at law, and many a life-long enmity would be entirely avoided if the principals would temperately define the terms of their differences.

The character of the technical man's language is important in his social and business intercourse; in his business and professional correspondence; in the promulgation of orders, rules, and regulations for the guidance of those under his direction; in the preparation of specifications, contracts, and reports; in writing and delivering addresses and

technical papers; and in writing technical books for the advancement of his profession.

In conversation, earnestness and force may, in some measure, counteract the evil influence of bad English; but, since less care is commonly given to the spoken word than to the written, the results of bad habits of speech are much the same in either case; and in moments of special interest or excitement the habitual language is employed. Speech is usually heard but once, therefore its errors are much more likely to pass unnoticed than those which are written and may be read repeatedly; and the audience of the speaker is much more limited than that of the writer; therefore it would seem less important to speak than to write correctly. But it must not be forgotten that in conversation there is no time, as a rule, to give thought to the form of speech; and that all the errors one is accustomed to make are liable to occur. The habit of using good English should be so firmly fixed that one is not conscious of it.

A technical man is, presumably, an educated man; and if he do not speak like one, suspicion is cast upon the entire range of his learning. When a man cannot spell correctly, or use ordinarily good grammar (and there are many university men who cannot) it is difficult to convince others that he is professionally able. The great majority of technical men occupy salaried positions in the organizations of railways, governments, constructing companies, and manufacturing corporations. These positions are obtained by means of acquaintances made in a social way, by interview, by correspondence, or on account of an earned reputation. Yet I have granted interviews to many technical men who spoke like laborers, and have received hundreds of letters from them that would be a disgrace to a grammar school scholar. There are technically educated men who say "I have saw," "I seen," and "I done"; and there are men in high places who require no further proof of the speaker's deep ignorance, not only of English but of technical matters as well. One who is thus ignorant of the language finds social progress substantially impossible. This may seem a trivial matter and foreign to our purpose, but it is not. Matters of very large importance are often settled by favor, and favor frequently follows social position. Other things being equal, almost anyone will show his friend the preference in business or professional matters. It is even common to stretch a point in favor of a friend.

Language has large weight in classifying a man, infinitely more than manner or dress. It exhibits his breeding and indicates his social status. I do not mean that it shows whether he belongs to the so called "Smart Set," but whether he is of the educated, cultured class,

whether you would care to entertain him at all, and, if so, whether you would send him to your less or more select club, or whether you may extend the extreme courtesy of inviting him to your home. This may appear at first glance to be of small consequence; but great things often result from associations quickly formed. In fact, such social relations make largely for success or failure in the business or professional world. Many have received the opportunity which led to eminence through the recommendation of a casual acquaintance who was favorably impressed.

There are many vocations in which it is not essential that a man be cultured and intelligent; but the technical professions are not among them. Nothing so surely marks a man's secret habits of thought, his real character, as the little tricks of speech which are exhibited when his mind is upon the matter rather than the manner of his speech. If his thought be habitually coarse, crude, or brutal, his speech will make the fact manifest at times; and the speech of a moment frequently produces a permanent and vital effect.

In business correspondence the value of good usage is still more manifest than in conversation, since the written word is permanent, and correspondence greatly extends the field of one's intercourse. A letter very probably passes through many hands and multiplies the good or bad impressions of the writer it produces. If its import is not clear, it may cause disagreement or involve serious financial disadvantage to the writer. Even bad punctuation will often seriously alter the entire meaning of a sentence, and particularly bad grammar at once stamps a writer as being more or less of an ignoramus. The art of letter writing, like a knowledge of grammar, is commonly considered to be within the range of everyone's learning and skill; but anyone who has had large experience in business correspondence knows that few men write good letters. It is so rare to find a matter which is composed of more than one or two items, clearly, concisely, and thoroughly discussed in a letter that favorable attention is immediately attracted to its writer. Not a few men owe the opportunity for advancement to their ability to write a good letter. Even though one be thoroughly versed in his subject and his discourse be well worth the time and attention of men of affairs, bad grammar will cast such suspicion over his whole equipment of learning that his argument will often be put aside without substantial consideration. Bad grammar is not a bar to the acquisition of money, but it substantially prohibits the acquisition of high position in the scientific world.

The detrimental results of bad English in conversation or in correspondence are by no means so certain as in the more formal

technical papers. In the preparation of articles for the technical press, and papers for the learned societies, there is time to study form and style and to eliminate errors due to haste; hence, when such matters are ill written, it is not unfairly argued that the writer is ignorant of the correct use of the language. Such an opinion, widely disseminated, as it is likely to be when it originates thus, is exceedingly detrimental to the writer. It weakens his arguments, causes him to be misunderstood, or so detracts from the interest of his readers that the matter is not read. The idea that a technical paper is dry at best, and that the English employed in it is of small consequence has long been proved incorrect. There is so much nowadays that is well written that no busy professional man is willing to spare the extra time and effort necessary to read and digest an ill written paper.

A merchant may advertise his wares, a manufacturer his product, but reasonable modesty and his code of ethics prevent a professional man from advertising his skill. If he does not become known by his work or his writings, he remains in comparative obscurity. His ability is clearly exposed in his writings, in which he gives to the profession his best thought; and if he cannot write easily and well he will probably not write at all, for the censorship of the learned societies is now severe and is rapidly growing more so. Every normal, healthy-minded technical man desires to leave a permanent record of the results of his best thought and work to aid his co-workers and those who come after him. An ably written description of work performed, discoveries made, or methods developed accomplishes more for the advancement of science than many well designed and well executed constructions. The latter benefit those who see them; the former may help all who can read.

Provoking and expensive errors often arise from the misunderstanding of badly expressed orders, rules, and regulations. In large corporations, especially in railway, contracting, and engineering companies where employees are distributed over a wide area, it is impossible for an officer to give individual instructions, or to see personally that they are carried out; hence, general instructions must be so clear that they cannot be misunderstood or evaded. It is hardly necessary to say that the consequences of a mistake in train orders, in instructions regarding breaking track for repairs or renewals, or for making temporary construction to span washouts, may result in expensive and fatal accidents. And even minor errors, oft repeated, may prove very costly.

But the preparation of reports, specifications, and contracts is

the most particular and momentous task the technical man has to perform. A misused word, a phrase whose meaning is ambiguous, a paragraph that is confused, or the omission of a direction or a precaution, may result in great damage, to both the client and the technical man. It is not enough to be careful in a general way. Every word, every phrase, every sentence, has a direct and vital bearing on the work governed by the documents. I have known the presence in a contract of a single word of equivocal meaning to cost one of the parties many thousands of dollars, though when the contract was drawn there was no question regarding the intent of the parties to it. Probably the majority of the civil law suits are caused not by trickery or deceit or dishonesty, but by the use of ambiguous words and phrases, bad ordering of the matter, incompleteness, and other faults in the language of the correspondence, specifications, and contracts. There is no more certain way for the engineer to protect his own and his client's interests than to prepare all documents in accordance with the best English usage as well as with technical skill; and there is no surer way to lay the foundation for trouble and financial loss than to neglect the character of his language.

Notwithstanding the vital importance of clear, concise, and full expression in such documents, it is not uncommon to find specifications and contracts so bad in their construction that they fail utterly in their purpose. Let me quote an illustration from the specifications, prepared by an architectural firm of some repute, for the construction of a building which cost nearly one hundred thousand dollars.

"Material and Workmanship. The entire frame work, columns, beams, etc., as indicated by the framing plans, or as specified, is to be of wrought steel, of quality hereinafter designated, all materials to be provided and put in place by this contractor. All work to be done in a neat and skillful manner, and is to guarantee the construction and workmanship with a bond equal to amount of tender for a term of five years, satisfactory to the proprietor and architects, to properly carry or support the loads it is designated to carry, namely its own weight, the weight of the several floors, roof and walls resting thereon, a 10,000 gravity tank, and the pressure of any wind which may not be designated a hurricane, and future three stories. * * * The floor beams are to be calculated for a maximum load of 150 lbs. to the sq. ft. (using C type IV of the Clinton Fire-Proof system, of Clinton, Mass.). The columns are to be calculated for a vertical load above mentioned and for horizontals and wind pressure and snow pressure, also roof. The whole to be calculated

heavy enough for three additional stories on building should they be put on at any time, with connections at top columns to receive future columns. The columns on ground floor supporting front to be calculated in same proportion with all the rods necessary where shown. The whole of the columns to be one size throughout, those that carry more weight reinforced, and all columns to be kept as small as possible in proper construction. Each column to have ⅜-inch holes bored or punched every 4 ft. 6 in. in height on each corner (for use of other trades to fasten metal lath)."

The building was constructed under these specifications, not according to them; that would be impossible. But it is hardly necessary to say that the proprietors interested were not safe-guarded. The wretched paragraphs quoted are no worse than a contractor finds in specifications almost every day, for they are composed, as a large number of engineers and architects compose their specifications, by copying and combining sentences or paragraphs from various sources, instead of by writing them from fundamental knowledge of the construction desired. In such instances the client is protected infinitely more by the honesty, knowledge, and skill of the contractor than by those of the architect.

Very few railway specifications for complicated structures are so well written that a contractor cannot comply with them to the letter, yet give the company construction far inferior to what the writer of the specifications intended, and thereby gain for himself material advantage.

The lawyers and the courts are kept busy rectifying the blunders of other professional men who do ill what they are paid to do well. I know of one contractor who has grown gray in the business of constructing buildings, who has never completed a contract without a lawsuit, and who has never lost a lawsuit. This speaks ill for the work of the architects under whom he worked, yet they are probably no worse than their fellows. If it were not good policy to be reasonably honest, many another contractor might easily approach his record.

It would appear that we have given more attention to bad than to good English. This is not illogical, for, manifestly, if the bad be eliminated the good will remain; and if the evils arising from the abuse of the language be fully comprehended, there will certainly be serious endeavor to improve the usage. The laws of the language are commonly violated from mere carelessness. Slang and provincialisms creep into the speech and destroy its force and elegance; the expression becomes slovenly and the thought obscure; and what

constitutes good English is forgotten unless reasonable attention is paid to the speech.

It is not given to every one to speak and write fluently, for style of the highest order is a rare gift; but if good, vigorous English be employed, a good, clear, characteristic style will soon be developed, the thought will be well impressed upon the audience, and the influence of the writer will be correspondingly strengthened. Facetiousness, fine writing, and poesy are rarely of service to the technical man. Invective should almost never be employed. Sarcasm should be used sparingly; and nothing should be written in anger. Remember that "whom the gods would destroy, they first make mad," and wait till your anger has cooled; then your just indignation may be much more effectively expressed in firm but moderate language. This is quite as much a matter of language as of policy and ethics, for violent language is always more violent than the user intended it to be.

Language itself is merely an instrument. Beautiful English does not constitute a meritorious discourse. The speaker or writer who uses language correctly and fluently but expresses no important thought is a failure; for the sole service good English can render is to convey the speaker's thought and purpose fully and accurately to the minds of his auditors. But this service alone will amply repay years of study and a life of care and attention to the use of the English language.

It may not be out of place to mention here a number of books which I feel certain will be found helpful.

A number of grammars published in this country set forth the rules clearly and there are several good etymologies, but "Mason's English Grammar," published by Bell and Son, of London, contains, in addition, much historical matter which aids remarkably in comprehending the subject.

Lockwood's "Lessons in English" and "A. S. Hill's Rhetoric" are very good elementary books, and "Genung's Rhetoric" is the best of the more advanced works on composition.

"Every Day English" and "Words and Their Uses," by Richard Grant White, are among the best written and sanest books which treat of English usage. They are substantially free from pedantry, a rare quality in books of this class. "What is Good English and Other Essays," by Harry Thurston Peck, also treats this subject admirably, though it should be read only after a sound knowledge of the technique of the language has been acquired.

There are a number of good dictionaries. "The Century" is the most complete and scholarly, with the possible exception of an elaborate work now being issued in parts from Oxford University. But "Webster's International Dictionary," "Worcester's Dictionary," and the "Standard Dictionary" are good, serviceable compilations. There are several good books of synonyms, and "Roget's Thesaurus of English Words" will also be found very helpful in finding just the right word.

Winchester's "Principles of Literary Criticism" is not only one of the most ably written works on the subject, but is itself one of the finest examples of good English we have. Sidney Lanier's books, "Music and Poetry" and "The English Novel," are also excellent critical works.

This list may be greatly extended; but a thorough study of one or two good books which treat each phase of the study of English, the reading of literature of the best classes, and reasonable watchfulness over one's every day writing and conversation, will inevitably result in habitually correct use of the English language.

THE NECESSITY FOR INDIVIDUAL ENGINEERING LIBRARIES AND FOR CONTINUING STUDY AFTER GRADUATION.

By

John Lyle Harrington, Consulting Engineer.

As in the case of the last paper, the Editors are not at liberty to comment much upon the contents of this address; nevertheless they are constrained to make the statement that any engineering student who fails to follow the advice which it gives will all his life have occasion to regret having done so. Consequently, both the entering freshman and the recent graduate are earnestly urged to "read, mark, learn, and inwardly digest" all that the author says and be governed accordingly.

This address was delivered in 1908 to the engineering students of the University of Missouri and of the University of Kansas, and was afterwards printed in pamphlet form and widely distributed among engineers, professors, and students. The universal endorsement which it received is a sufficient proof of the correctness of the precepts which it puts forth, and an irrefutable reason for advising all engineering students to be guided by them.

Editors.

THE NECESSITY FOR INDIVIDUAL ENGINEERING LIBRARIES AND FOR CONTINUING STUDY AFTER GRADUATION.

By

John Lyle Harrington, Consulting Engineer.

Substantially every engineering graduate aims to achieve success along professional lines; otherwise his education is largely a mistake, for an engineering course, though it supplies mental training of a high order, offers very little that is cultural, while a well chosen academic course affords equal mental training and, at the same time, provides the broad, general culture which is so advantageous in every vocation. Fame and position may be attained as a technist purely; that is by confining the attention wholly to the design of engineering works; for cities, railroads, contractors, and the manufacturers of bridges, locomotives, engines, electrical apparatus, and other lines of machinery need such men and value them highly. Or, with a sound knowledge of the technical work for a foundation, success may be won as a salesman or as a manager of sales; as a publicity officer or advertising manager for manufacturing companies; as an engineering educator; as a manager of works and construction; as a business or contracting manager; or as an executive officer in any corporation whose business is based upon engineering.

Both money and position may be gained as a contractor in the construction of engineering works; and the field of technical journalism offers high rewards. But the highest professional position is to be gained as an engineer in the broadest sense of that term. This requires the greatest possible technical skill, both theoretical and practical, in some important specialty and its allied branches; and sound knowledge of the methods and the business features of construction, of the law of contracts, of the financing of engineering projects, and of accounting, including under that term not merely the bookkeeping relating to construction, but the consideration of operation, repairs, renewals, sinking funds, and similar financial matters.

Many qualifications are required for a high order of success. That one must have health goes without saying, for without health and strength there cannot be hard and continuous labor, either mental or physical; and success of any kind demands both. Intelligence is neces-

sary to grasp the most abstruse principles of mathematics and the pure sciences and to apply them to available resources. Energy of the highest order must be employed to study principles, men, methods, and materials and to bring them together so that useful works shall result. Integrity is absolutely essential to high professional success; for the engineer's position is frequently judicial, and he must bring to his work all of the spirit of fairness that is given to man. The individuality and initiative to do original, thoughtful work is another essential without which the engineer becomes a hack or a grind who, though a useful cog in the machine, does little to advance his profession. But all these qualifications count for little in the struggle for professional success unless they are supplemented by a sound engineering education. Thirty years or more ago a great many eminent engineers obtained at least their technical education by their own efforts. Then the profession was comparatively undeveloped, technical literature was meagre, and it was much easier than it is today to learn all that was most important of any one branch of engineering. Self education is possible now, but it is rarely broad, and it generally fails at the critical moment. The man who has educated himself rarely has the training necessary to keep pace with the advancement of engineering science, and he is much more apt to be a "rule of thumb engineer" or a copyist than an original thinker. Nowadays graduation from an engineering school of good standing counts for so much that only the lower positions are, as a rule, open to the man who is without it. Graduation is a guarantee of a certain training, and employers demand it.

The technical course, however, is only the beginning of an engineer's education, the first stretch of a long and interesting but difficult road. The present requirements for admission to institutions of the first grade are as high as, too often higher than, the secondary schools are prepared to satisfy, and the four-year courses are crowded well nigh to the limit of the capacity of the average student; yet the engineering graduate is taught only the elements of a few important branches and is left substantially without knowledge of many subjects which are closely allied to any specialty he may choose. This is not the fault of the schools, for it is their function to perform the greatest possible service to the community which supports them, rather than to maintain certain ideals; but it is due to the inability or unwillingness of the student to spend the requisite time and energy upon his education. To raise materially the requirements for admission or to increase the length of the course would diminish greatly the number of students; and, while the few would be better prepared, the community as a whole would not be so well served.

There is at present a strong tendency to require more work of the engineering graduate. President Schurman of Cornell University is advocating a five-year engineering course, as Dr. Waddell has been doing for more than twenty years. Dartmouth and Cornell urge a special academic course which leads to a bachelor's degree and includes sound training in mathematics, languages, and the natural sciences, and which is followed by a two-year course in purely technical work, leading to the professional degree. Several institutions are offering five-year courses, and many provide a year's graduate work for those who are willing and able to prepare themselves more thoroughly than usual.

Engineering educators very generally recognize that our graduates are lacking both in culture and in breadth of technical knowledge; and they are earnestly seeking means for improvement. Some prominent professors are beginning to demand a collegiate education in preparation for the engineering study, just as such training is now required in many Eastern Schools in preparation for the study of law and medicine; for it is evident that the engineer needs for his highest development more training, more and broader knowledge, and more culture than he commonly possesses. The enormous increase in the number of students pursuing technical courses ensures very keen competition in all branches of engineering; for, though the field is widening rapidly and during the recent period of remarkable prosperity the demand for engineers was greater than the supply, the day is not far distant when employers will be more at liberty than they have been to select men especially suited to their needs. Then the law of the survival of the fittest will operate more truly; and education and training will count for still more than they do today. Then, even more certainly than now, only the ablest and best educated men will sit in high places and ordinary talent will remain in the ranks.

Now I want to state in the most emphatic terms at command that, no matter how high the standard of your school, when you graduate your education is only well begun, that if you do not continue your studies with as much or more vigor than you have commonly employed, you will have exceedingly small chance to win fame or position. You will be left standing at the post, and the races will be won by men who know their deficiencies and who take prompt and energetic steps to remove them. Your shortcomings are not limited to ignorance of subjects you have not studied. As soon as you are called upon to apply commercially the technical knowledge acquired while in school, you will become painfully aware that both your best efforts and those of your instructors have not given you such command of the facts and

principles of engineering that you can employ them with facility and assurance. During your course there was not sufficient occasion for applying the knowledge you gained to make its use a habit, and since completing the study of many subjects there has been time to forget much of them.

The great danger comes when you leave your *alma mater* and go out to take your place in the world. The man whose diploma is fresh is rarely given work which demands the immediate use of his theoretical knowledge, even that relating to one subject. The more mechanical work of drafting, inspection, or running an instrument is what he can do best, and, consequently, what he will be given to do; and it may be years before his duties attain such a breadth that the entire range of his technical knowledge will be called into play. When the demand does come it will come suddenly, and often it will be unrecognized. Then woe unto him who has considered his technical course all sufficient, for he will be like the foolish virgins in the parable, he will lack oil for his lamp and there will be no time to get it. He has not only failed to study and grow as the years passed, but he has lost a large part of the knowledge he spent four years to gain; and the prize is not for him.

Let me illustrate by citing a few of the many instances which have come under my observation. Though each case will show only a single failure, it will indicate clearly the general status of the knowledge possessed by the engineer in question.

One man, after six years in the bridge shops, could not calculate the stresses in a Warren truss produced by static loads. Another, after spending twelve years detailing and inspecting bridges, could not determine the stresses produced in a beam by a locomotive. Another who had spent eight years detailing bridges and structural work could not find the reactions from a simple cantilever crane. Still another of seven years' experience could calculate graphically with facility but could do nothing analytically. One man was found to be unable to make a stress sheet for a parallel-chord, Pratt-truss highway bridge, though he had spent nearly three years in one of the best bridge shops in the country. Another who had been employed for two years in the office of the bridge engineer of one of the prominent railroads could not find the position of two wheels which would produce the maximum moment in a beam. An electrical engineer of four years' experience, when working out some electric locomotive problems, considered the grade in per cent to be numerically equal to the degrees of angle between the track and the horizontal. This error ultimately cost him a position which afforded a salary of thirty-five hundred dollars a year.

An experienced mechanical graduate was astonished to find that the speed with which steam will travel through a port is calculable. Another found it impossible to conceive that a steam turbine is operated by the impulse instead of by the pressure of steam. And I have known several experienced mechanical men who could not determine what series wound motor is required to hoist a given load through a fixed distance in a certain time, because they could not read the performance curves of the motors.

Since you may say these are isolated cases and, consequently, prove nothing, I shall cite one more which is so sweepingly general that it seems incredible. A prominent bridge company wanted another designing engineer. They employed about seventy men, substantially all technical graduates, in the detail drawing rooms. In the course of a few months the chief engineer tested every man of promise among them to see if one could not, in reasonable time, be trained to fill the position; but all so lacked theoretical knowledge or facility in its use that an engineer was obtained elsewhere at twice the salary received by the best paid man in the drafting rooms. Probably every man of the seventy would gladly have taken up the designing work for less salary than he was then receiving, but not one was prepared and ready.

I might cite many more such examples, but I think abundant have been presented to convince you that the technical education must be carried on vigorously and continuously after graduation, if positions much higher than those of skilled workmen are to be attained. Without exception, the men mentioned in the individual examples I have just cited were graduates of Eastern engineering schools of the highest standing. They had every advantage which you have now or will have when you graduate, unless you possess the energy and foresight to acquire and to study thoroughly and persistently a library of the best books, periodicals, and technical society papers which relate to your specialty and its allied branches. If you avoid this work and try to cope unaided with the many problems which will confront you, you must inevitably fail and occupy through life a very subordinate or at best a secondary position.

Let us examine the undergraduate course carefully in order to determine what it accomplishes, what are its limitations, and how you may, while still in school, strengthen yourselves against the day when you are turned out into the world to sink or swim professionally; when you no longer have within reach instructors ready to help you over the rough places and to guide and direct you at need.

The first two years are devoted almost exclusively to the study of mathematics, languages, and the natural sciences, subjects which afford culture and excellent mental training, and form the basis for the technical work, but are in themselves not at all technical. During this period the student's capacity for study and his ability to grasp a new subject are greatly improved, but only two years are left for the technical work; and it taxes the ingenuity of the Faculty, and sometimes the strength of the student, to cover in that limited time all of the more important fundamental subjects relating to any branch of engineering. Many closely allied subjects must be left untouched, and there is time for only the elements of many of those considered. It is impossible in the time available to make a deep and comprehensive study of any one branch without neglecting other important subjects.

President Woodrow Wilson of Princeton University has recently argued before a meeting of teachers that our educational methods are all wrong, that we teach too many subjects and no subject thoroughly enough. There is a measure of truth in the statement, for it is better to be well versed in some one line, so well that the knowledge is constantly available for use, than to know something of many lines, but so little of any one that the knowledge is not of much service. It is always difficult so to draw the line between deep preparation and broad preparation that the greatest good will result. In fact no general rule will apply, but the courses must be laid down for the average student in accord with the Faculty's best judgment. Some men would be benefited by more concentrated work, for they may tend naturally to breadth; on the other hand many men would, if possible, select easy work under the guise of seeking breadth, and thus fail to obtain the necessary training.

Most students desire and many engineers urge that more practice be taught, and that the relations between theory and practice be made clearer; but educators have wisely refused to comply with these demands, for to do so without increasing the time required for the course would crowd out essential theoretical studies which the graduate is not likely to pursue unaided. Students generally expect to be finished, practical engineers when they graduate; and many practitioners think that the schools should leave the graduates little to learn; but thoughtful engineers realize that the schools serve their highest purpose when the whole course is devoted to fundamental, theoretical studies and only enough practice is taught to illustrate principles. The training that results in the ability to grasp new ideas and in the habit of concentrating the mind upon any matter in interest is everything; the knowledge of a few facts more or less is nothing. Every time

a student leads his instructors to believe he has mastered a point when he has not, he cheats himself not out of so much learning but out of the ability to learn. He has handicapped himself permanently for the sake of an hour of ease, left himself a little nearer the position of the untaught laborer, and depreciated a little more his chance for success.

As soon as he begins his professional work, the graduate commonly renounces all thought of further study of principles and devotes his whole time to the study of practice. Theoretical studies are commonly crowded out of his field of effort, and what he has not learned about them while in school generally remains unknown, therefore the technical courses offered nowadays are right in principle, since they are composed chiefly of fundamental subjects.

Neither would it be wise for the schools to permit specialization much, if any, more than they do now. It is rare for a student to know positively what branch of engineering he will make his specialty. Civil, mechanical, electrical, mining, chemical, and metallurgical engineering, each has many subdivisions so important that few can practice successfully in more than one or two of them; and it is difficult to know in advance of actual work for what branch one's taste or mental attainments best fit him, or in what line opportunities will occur; therefore the education should be so broad that any specialty may be chosen and practiced with success. It is not uncommon to find great deviation from the intended course, men educated as civil engineers practicing in mechanical lines, and mechanical engineering graduates doing civil or electrical work. Even if the specialty practiced could be predetermined, the advantages of special preparation for it, within the limits of the four-year course, would be more than offset by the narrowing effect of crowding out other important subjects; and an error in choosing a specialty would probably result in mediocrity or failure, for great opportunities do not occur frequently; and if they cannot be seized promptly, they are generally lost. Therefore it is essential that your education be both broad and thorough, if the greatest success is to be obtained.

There is frequently a tendency for students to regard lightly the professional ability of their instructors, to consider them theorists who lack practical knowledge and whose opinions, therefore, must be accepted with caution. Once in a while there is reason for such an attitude, for the teaching branch of the profession is as subject to frailty as any other; but as a rule, these opinions spring from eagerness for practical work and the habit of regarding the theoretical studies as a necessary evil, a groundwork, which it will not be essential to recur to, once active practice is begun.

The true value of the scholastic work is not realized. It is frequent to hear objections on the part of the student to this or that study because it is not practical; because, so far as he can discern, it has no bearing upon designing and constructing engineering works, which in his opinion constitute the sum total of engineering. The study of English is especially subject to such criticism; just as though it were not necessary to employ the language understandingly in the preparation of specifications, contracts, and advertisements; in instructions to other engineers, to contractors, and to foremen; in technical papers and books; in business correspondence, prospectuses, estimates, reports, and other business papers, as well as in the social relations. It is singular how prevalent is the idea that this, the instrument most commonly used of all, the one upon the quality of which all others depend, should be considered of little consequence. If you have neither knowledge to gain nor thought to convey, the study of English is evidently useless; but, in that event so is the study of every other subject.

An engineer, of all men, requires such knowledge of the technique of the language that he can use it with accuracy and facility at all times. The bad construction of a sentence, even the erroneous use of a word or the misapplication of a comma, may result in costly litigation and heavy loss; therefore the language merits far more study than the best technical courses provide. Even if you have excellent habits of speech and write good English readily, you will find, upon close study, that habit cannot be depended upon for satisfactory technical English. Close, careful study of diction and construction is essential in any case. The reading of well written technical works, of the English classics, and of the best current literature will aid greatly in the acquisition of correct habits; but this is not enough. Make the study of the language habitual or you will find, when you have advanced so far in your profession that you have engineering and legal papers to prepare, that you blunder grievously in your use of English. I know an engineer of unusual technical ability who has twice tried and twice failed to establish himself in independent practice and who still occupies a secondary position, largely, in my opinion, because he speaks and writes like an ignoramus.

A knowledge of chemistry is likewise universally essential to the engineer, no matter what specialty he practice, for the relations of the constituents of the materials employed in construction are always important and often vital; and if they are not understood, the materials cannot be used intelligently.

Foreign languages are not technical subjects; but they aid in keeping one thoroughly informed; for only the best things to be found in

them are translated into English, and the publication of the translation is commonly far behind that of the original.

Other subjects which do not deal directly with design and construction are required for similarly good reasons, which only active practice will make clear; therefore the student's objections to the subjects he is obliged to study are commonly illfounded, and if any of them are slighted during the course, in all probability it will be necessary to remedy the deficiency later.

As soon as possible after graduation the embryonic engineer obtains a position and enters upon his professional career. If he has a choice, he generally takes the one which pays the most money immediately, though the ultimate compensation in any branch of engineering is inversely proportional to the salary paid the beginner in it. If he has a well defined idea of what line of work he desires to follow, and if he has been fortunate enough to obtain a position in that line, he will probably employ all his energy to learn everything practical about his immediate tasks and whatever else comes directly under his observation. Often the work of more experienced men is studied zealously to the neglect of his own. He will, if he be energetic, drive with all his strength at the practical work and begin to calculate upon how soon his salary should be increased. If he is in the field, he sees skilled workmen paid much more than he is; and, because he knows the workmen have not his education and could not do his work, he exaggerates the value of his services and often begins to have a grievance. He does not realize that he knows very little about his broad line of work, while the skilled mechanic is well trained in his narrower line and, consequently, is better able to produce saleable results.

Almost every young engineer is inclined to minimize the amount he has to learn and to seek to reach the top in a few short leaps. I remember one very bright young man who entered the detail drawing room of a bridge company immediately after graduation. Within a month he applied for transfer to the designing rooms, because, as he stated, he had learned all there was to be learned about detailing. He was transferred; and for some months, under the impression that he was estimating, he contentedly calculated the weight of steel on lists furnished him by the designers. He learned so fast, in his own opinion, that it is not surprising that in eight years he has attained a very mediocre position. Every man who, when he graduates, thinks he knows all but a little of the practical work, which he can learn in a few months, will make similar progress unless some shock opens his eyes to the truth.

Though this extremely comfortable idea of the graduate's equipment is not very general, the estimate the young man usually places upon the extent of his knowledge is almost universally far too high. It is common to assume that the education is finished, that the text books are properly put away like other childish things, and that it is only necessary to go forth, learn practice, and conquer. And since that course requires the least possible amount of energy, it is very frequently followed for years; so long that when the need for further study is finally realized, the mathematics and the elements of the theoretical work obtained in school are forgotten, and the task of reviewing them and acquiring further knowledge of them is so great that it appalls and discourages, and the man remains for the balance of his life a draftsman, an instrument man, or a secondary man of some other sort. He will attribute his own failure to the malice of enemies or the lack of powerful friends, and the success of his acquaintances to influence or luck. He will rarely admit, even to himself, that he failed because he deserved to fail, because he was unwilling to work for success. Is the picture distasteful? I hope so. But do not get the idea that it is exaggerated. I can call the names of many men whose advancement has been imperceptibly slow because they proceeded along such lines, and every engineer has watched the course of many who have been left behind because they would do only the work given them to do and would set and perform no tasks for themselves. And I have known many others who have gone forward rapidly because they think, read, and study continuously.

There are, of course, differences in the amounts and kinds of ability with which nature has endowed men, and it is very easy to attribute your own failure or another man's success to these qualities over which the individual has no control, but I firmly believe that by far the larger influence is common industry, or the lack of it. And I assure you it requires much more energy to think out a course of study and pursue it than it does to perform your daily task well. Energy is necessary to perform manual labor or routine mental labor, but infinitely more is required to do original work or to pursue a course which is not obligatory and which will result in no immediate benefit. It is the custom of mankind to forfeit large but long deferred benefits for the sake of small immediate ones.

When a young man takes up his first work, he gives his best thought, as he should, to learning to perform the tasks which will provide his living; and if he has not already a bit of a library and the habit of using it and increasing it, that is about all he will do except to satisfy his desire for recreation and for social pleasures. He has

little immediate use for his books and he forgets them and their contents. His duties do not require knowledge of law or organization or management or business or finance. These are not, he concludes, engineering subjects, and, consequently, can be of no interest to him; therefore, he gives them little or no thought. In the course of two or three years, if he has been industrious and thoughtful in his daily work, he will be given tasks which make greater demands upon his technical knowledge. Then he must go back to his text books and review them before he can with assurance do the work properly. This takes time, for he has forgotten much, and, in order to escape criticism for lack of facility, he will probably try short cuts or guess work and fail. This is the usual course, because men employed by large corporations generally acquire such extreme respect for the organization and for the opinions of their official superiors that they will adopt almost any means to avoid severe criticism. In the bridge shops, for instance, there is commonly a very un-American fear of "The Boss," which arises partly from the superior knowledge and position of the official and partly from the possibility of criticism for ignorance or, more commonly, for lack of industry and attention to business. It is deplorable but undeniable that technically educated men have to be watched and urged, much as the lower orders of workmen do. But haste due to fear of criticism and the laziness which prevents study frequently cause grievous blunders. False pride which prevents confession of ignorance is also a fruitful source of error. It takes courage and honesty to say, "I do not know," but courage and honesty are among the essential characteristics of a successful engineer.

I have said before that the engineering graduate is rarely called upon in the earlier stages of his professional work to use much of his technical information; and that, in consequence, he forgets it. This is especially true of those who take up field work. Their knowledge of instrument work is brought into immediate service, but in a very short time mechanics, the basis of all designing, will have become but a name. One of my acquaintances, who has spent in the field the most of his twelve years since graduation, recently told me that he was re-reading his mechanics and was astonished to find how little he knew of what was once thoroughly familiar to him. Undoubtedly he has learned much in field work, but he has actually lost ground in some lines and grown narrow. That is the usual course and the one certain to result in the man becoming a cog in the wheel and a little one at that. Many a technical man calls himself a bridge engineer and looks upon himself as a specialist who is cheated out of his dues; yet is versed in only one narrow branch of bridge work, such as shop drafting, inspection, or estimating. He probably knows little or

nothing of shop work or erection or management or business or the higher technique of designing; yet he would bristle with indignation if you were to tell him he is narrow and that he does not know his business. He has steadily followed a single phase of a single branch of a single division of engineering, because up to a certain point he could increase his salary most rapidly by so doing. He became proficient in his narrow line of work, and he refused to take up other lines because he knew less about them and could earn less in them. And so he reached a certain position and remained there because his foundation was too narrow.

It is urgently necessary that the recent engineering graduate shall at once take steps to master thoroughly every phase of the specialty he means to follow, including many allied technical branches, and, at the same time, to broaden his view by studying other and more remote lines. There is so much to read and study, so many lines to pursue, that, unless he have the wisdom and foresight to work according to some plan, confusion and weakness will result. Knowledge is of value only as it is of use, and if it lack cohesion, is not gathered and arranged in the mind according to some system, it is almost useless. Many a man reminds me of my first shot gun. It made a big noise and kicked vigorously; whenever it went off you felt sure the game must come down; but it scattered so badly that it was rather more apt to miss than to hit. The shot would strike all around the bird, which would often get off unhurt. Thus many a man shoots all around the mark but cannot concentrate his fire so it will tell.

Notwithstanding the necessary limitations of the technical course, if the student will do his part, he will, when he graduates, have the best equipment obtainable in the time employed. But he who performs his daily task and passes his examinations so well that he gets fair grades and in the end receives his degree, has not necessarily done his part. Good consistent work is much, but it is not all; in fact, it is only what the university demands in set terms. It obtains the credits and the degree, just as the ordinary laborer earns his daily wage; and it is little more likely to make the student an eminent engineer than the daily wage is likely to make the laborer a millionaire. Initiative and untiring energy to plan and carry out work which is not compulsory are even more essential and effective during the college course than they are at the height of the professional career. It is true that one who is only an ordinary student may awaken when he takes up his professional work and set for himself a pace which will enable him to reach the top; but as a rule he will never realize that he is not doing his best. He won his degree without great effort; and in

his opinion, it necessarily follows that success must come naturally and easily. After a while when it is too late, he finds it does not; then some one else or his luck is to blame, never himself. As a rule, it is easier to reform a drunkard than a drone or an indifferent man.

The graduate should understand that in spite of splendid equipment, able instructors, and rigorous discipline, the technical school does not turn him out a finished engineer, but leaves him to acquire the major part of the necessary technical knowledge after he has gone out into the world. It has given him methods of study, trained him to grasp readily the arguments of able writers, taught him the mathematics he needs, some foreign languages and something of his own, and the elements of some natural sciences, and it has made a beginning upon his technical education; but if he stops there, failure is certainly his portion. The school has accomplished its purpose, trained him mentally, but he must yet broaden and deepen his knowledge of theory, as well as learn the practical phases of his professional work. He must work alone. With rare exception his employers have neither the time nor the inclination to interest themselves in any portion of his life except that for which they pay. Occasionally he may be urged to exert himself to learn more about the work he is employed to do, but he must, of his own volition, plan and carry out the study which is essential to success.

The recent engineering graduate is not fitted to do much commercial work, and employers are loath to spend the time and patience necessary to direct him and to correct his errors. No one really wants to employ him, but he will be given place and work in the hope that ultimately he will become proficient and then repay in profitable service the time and effort spent upon him in the beginning. If he be energetic, he will be encouraged to learn the things which will make his services more valuable immediately, the practical phases of his work. But what about the things which count so much toward his ultimate success, yet have no bearing upon the work in hand? Will they be pointed out to him? Will he be urged to study more deeply the courses he pursued while in school and to take up the study of the collateral subjects which have a bearing upon the work he will be called upon to do five or ten years hence? Yes, in about one case in a hundred. Surely not much more frequently. He will generally be left to his own devices except in so far as he can be made more useful now or in the very near future. In many large establishments even that much pressure is not brought to bear, but he is left to succeed or fail as he will. If he earn his salary and if work should be plentiful, he will be retained; but much personal effort to aid the novice is considered an immediate loss, for the average man will move

on and deliver to another employer the benefit of such instruction as soon as he can obtain more money by doing so. Some of our larger manufacturers, it is true, seek recent graduates, bind them to a specific term of service, and maintain a course of instruction for them. In these cases the better men are selected for advancement in the company's service while the less competent or less energetic are retained as a sort of higher grade mechanic. I know one man who has been making shop drawings of plate girders for more than twenty years, for a mechanic's pay.

Even when employers or officers of corporations take a personal interest in the recent graduate and endeavor to advise him, they frequently find the effort wasted, if not offensive. Too many young men resent the advice to continue study as a reflection upon their intelligence and their equipment of learning. Sometimes egotism carries them so far that they think the older man is jealous of their superior knowledge; and the lofty manner in which they sometimes criticise the work of older men is often decidedly amusing. I well remember the uncomplimentary remarks two young graduates made about an eminent mechanical engineer and his design of a clam-shell bucket, though they did not understand even the operation of the machine.

Compare these conditions with those which obtain before graduation. The Faculty not only urge the student to employ his best efforts and suggest better methods of study, but substantially compel him to acquire definite amounts of valuable information in a given time. He is not obliged to take the initiative. The courses are mapped out for him in detail; even the daily task is set; and if the ability or the energy to grasp any portion of the subject be lacking, the instructor not only stands ready and willing to aid when called upon, but seeks the opportunity to help. The student has constantly in view definite results to be attained in given periods; such as the completion, first, of the subjects immediately in hand and, finally, of the whole course, the receipt of a degree, and the entering upon a career which hope and imagination make brilliant. Every aid and incentive to study are offered. Pride in his own strength and in his ability to achieve, and the hope and encouragement of his family, his friends, and his instructors, urge him forward. The way is made easy, bright, and pleasant. He has only to follow the course laid down and honor and success are his.

Thus the student is aided and advised at every step, while the graduate must map out his own course and pursue it with energy and steady purpose, if he is to win. The transition is abrupt, the test severe; and it is little wonder that so many fail; but the remedy lies altogether with the student. He must take the initiative and so lay his plans and conduct his work that when he graduates there will be

only a modification, not an interruption, in his course of study. He must prepare himself against the day of trial which is certainly coming, and take steps to supplement the university work.

Many of you, no doubt, consider yourselves hard worked to satisfy the Faculty's requirements; but, except in the rare case when lack of health and strength interferes, you will find that a reasonable amount of collateral work is not only pleasant and profitable, but that it actually lightens the required work by affording a broader and clearer comprehension of it. And you have time for it. If you ever reach a high executive position, you will find that instead of taking your pleasure and recreation very much at will, as you do now, you will make them a part of a schedule which accounts for almost every minute of your time. You will often excuse yourself, instead of ceasing work, when a friend drops in for a social chat; and you will forego many a ball or dinner or theater party or other pleasure for the sake of your work or study. In time you will come to smile with amusement when you recall how you thought you were busy when in school. The student is father of the practitioner, and I know that very few young engineers understand how to concentrate their thought upon what they are doing so that only imperative matters will interrupt them. And still fewer take such a comprehensive view of their work that the little, less important features of a task are not forgotten or neglected. Therefore, I fear that the student who thinks he is hard worked has much to learn about methods of study.

Primarily, you must do the prescribed work with all your energy and ability, set your own pace in it rather than be driven or coaxed along, and bring yourself to understand that the training you are receiving and the habits you are acquiring now are of the utmost importance to you throughout your professional career. If it be possible to do more work than has been prescribed (and almost every earnest, energetic student will find it so) choose the work which you prefer or think most beneficial, seek your instructors' advice regarding it, and then do all of it you can without detriment to the prescribed courses. Purchase other books which cover the same ground as the text-books employed. They will often present the matter in different lights and actually reduce the amount of work required to grasp the subject. I recall that an old work on analytical geometry, which treats the problems graphically, greatly aided me to understand the algebraic treatment of the prescribed text book; and Prof. Merriman's books on bridges frequently made Johnson's clearer. Every book contains important matter which is not to be found in other works that treat the same subject. Often different methods are presented; and at the least, the second reading serves by repetition to fix the matter

more firmly in the mind. The difference between like works in matter and method of presentation strengthen by bringing the judgment into play and training it, and by developing the student's habit of independent thought.

Again, to read in the technical journals and the proceedings of the engineering societies descriptions of such works as those of which the text-book or lectures treat, greatly aids in understanding the subject and in fixing it in the mind, and, at the same time, affords a glimpse of the connection between theory and practice. The reading of technical papers also teaches you where to find data and how to present them, and acquaints you with what is going on in the world. There is something new in every issue, something to excite your curiosity and stimulate your mind.

If the time and energy be available, it is very advantageous to purchase and read books relating to allied subjects which the prescribed course does not include. For instance, a thorough course in dynamo-electric machinery or in thermodynamics or in the metallurgy of iron and steel may be of great service to a civil engineer; and a course in architectural engineering, in mill building construction, or in masonry design is of the highest importance to a mechanical engineer. I recall a large rail mill roof designed by an able mechanical engineer, which had only itself and the wind and snow to carry, yet was strong enough to support a railway train as well. And a civil engineer's work in mechanical lines is often painfully crude. Yet the various branches of engineering frequently overlap; and any engineer should be prepared to do reasonably well work in other lines which are closely allied to his specialty. If the fundamental knowledge of these allied subjects can be obtained in course without interference with the regular work, so much the better, but sooner or later it must be obtained.

Yet the great value of the purchase and perusal of the technical periodicals and other than the required text books lies in beginning a library and in establishing habits of independent thought and study, while still in position to obtain friendly aid and advice from the Faculty. The files of the technical periodicals form a very important part of every engineer's library. Even the six or eight volumes of any good engineering paper which the student should accumulate afford many descriptions and illustrations of engineering works and of the methods of designing and constructing them. But the back numbers are difficult to obtain; and if the graduate does not have them, he is not likely to buy them, and, consequently, will miss their aid in solving his first practical problems. Without them his knowl-

edge of what has been done in the engineering world will not extend much back of the day he began work in his first position.

It is true that there are one or two copies of each of the best technical journals in the school's library and that they can be read, even though they are not purchased. But they will not be read. How many of you read thoroughly even a part of one journal? How many read none at all? And if you should read them, that would not serve the purpose, for they and the technical society transactions constitute a large share of every engineer's library, and you should have them for reference.

After graduation many a young engineer would take up the study of subjects which bear upon his work but which he did not study in school, if he knew what books to buy. But, as a student, he has not learned to select books, for the text books have always been specified, and he knows little or nothing about the respective merits of others. And rather than waste his money on ill selections, he commonly makes the greatest of all errors by purchasing none at all.

It is difficult to estimate the ultimate value of a dozen books and a single engineering paper purchased and read during the course of study. The technical knowledge is increased, the habit of independent thought and methods of independent study are established, additional books are made familiar and available for reference, and the nucleus of a library is formed. The graduate has already begun his professional work; the transition from school to the office, shop, or field is made without danger that he will consider his education completed and that he will, in consequence, cease to study and grow. The size of this beginning of a library is of infinitely less importance than the habits formed in collecting it. The little group of books, if he carry them with him, will constantly strengthen and support him in his work and keep ever present in his mind the need for more books and further study.

Many a student, instead of taking pride in the growing row of books on his shelf, sells even his text books as soon as he has received his credits in the subjects of which they treat. He burns his bridges behind him and makes certain that whatever he has not learned from his books will remain unknown, whatever was not clear will remain obscure, whatever he forgets will remain forgotten. When, in his later work, either before or after graduation, his memory needs refreshing or a point puzzles him, he cannot turn to the familiar pages and satisfy his needs. Instead, in fear and trembling he puts on a bold face and endeavors to convince his instructors or employers that he knows what he does not know. If he succeed, he has cheated both himself and them and has acquired a dishonest habit. If he fail, and

he generally does, though he may not know it, he not only acquires the dishonest habit and cheats himself, but he fails in his work and falls behind in the race. No other books will ever supply the desired information so readily as those he pored over in school. Even if the student has not the means or the foresight to begin his professional library by purchasing additional books, the required text books, if retained, form a valuable working nucleus. When the course is completed the days of a text book's usefulness instead of being over are only begun; and the man who sells his as soon as he can is already on the high road to failure.

It is frequently stated, sometimes by instructors, that the average student cannot afford to buy more books than are absolutely essential to the pursuit of the prescribed studies; but such a view is exceedingly narrow. Expenses vary greatly with the situation of the institution, the tuition charged, and the student's tastes, habits, and supply of funds; but four hundred dollars a year is probably a low estimate of the average annual expenditure, even in our state universities where the tuition is little or nothing. An increase of five per cent, or about twenty dollars per annum, spent for a good technical journal and for well selected engineering books will place within the student's reach the means for doubling his fund of technical knowledge. And what can be said of the economy of spending a dollar for half a loaf when a dollar and five cents would buy a whole one! I feel sure that the cases are few in which the lack is not the money to buy books but the intelligence to appreciate their value and the energy to master their contents.

Consult your instructors regarding the best books in each line and make memoranda of their recommendations. Likewise consult instructors in other lines of which you would like a knowledge and make lists of the books they advise and the order in which such books should be studied. Get the catalogues of the principal publishers; they may be had for the asking; and see for yourselves what is available. Study well the reviews of new books as they appear in the technical papers. Then buy as many as you can find time to master without neglecting your regular studies. If it be only one each term, that is much; if two, that is much more. And remember that the mere possession of the book does not serve the purpose. It is like your mind, valuable directly in proportion to the use you make of it. There is no known method by which a knowledge of the contents of a book may be acquired without reading and study, though the contrary idea seems to be prevalent. Mere possession or laying on of hands will not suffice.

I hear many of you say you have no time for extra work, that your instructors demand it all and more. But how many of you do not absolutely waste a half hour a day? I do not mean how many withhold that much time from your studies and devote it to social duties or pleasures, to recreation, or to exercise, all of which are essential to right living; but absolutely waste it, doing nothing which affords either pleasure or profit. Yet a half hour a day devoted to books will enable you to read several ordinary volumes each term. And the value of so much work, in the knowledge obtained and the habits and training acquired, is almost incalculable. You have so much to read, there are so many subjects just touched upon or not included at all in your course, that the earlier you begin your independent work the better. If you wait till you have nothing else to do, you will never begin. You must make room for such work. You will find that doing only a little regularly will strengthen you and will rapidly increase your capacity for work, and you will be astonished to see how much a half hour a day well employed will accomplish.

The majority of engineering students have not found it possible to pursue wholly or in part an academic course, hence it is very important that they read as much as possible in non-technical lines. And much valuable knowledge and training in the humanities, in the languages, and in sociology and political economy and finance may be gained while reading for recreation.

In your reading while in school do not reach out too eagerly after the practical phases of your subjects. Remember that the theory is the more difficult part to obtain unaided and that after graduation you will be obliged to make special effort to gain further knowledge of it, while you will necessarily learn much of practice in the ordinary course of your work. Seek to establish the principles which form the basis of your future tasks as thoroughly as possible in your mind and to acquire all the knowledge of them your time and strength will permit. Build your foundations substantially, and the superstructure will be much more certain to serve its purpose.

The discussion of technical problems in the undergraduate engineering societies is a very effective means of developing sound methods, for it enforces precise and comprehensive thinking and necessitates the reading of the technical papers and other books than those required for class use. No one wishes to advance theories or make statements which are not supported by facts or sound logic, therefore earnest thought commonly precedes discussion or argument.

Immediately after graduation review thoroughly all your text books that bear upon your work. Then map out a course of technical study, select and purchase the books needed for it, and, if possible,

devote to it a certain amount of time each day. You will be astonished to find that with an hour a day well applied you will cover more ground than you did with all your time while in school, for you acquire better methods of study and greater mental grasp with the passage of years.

At the same time, subscribe for at least one good engineering weekly and read it thoroughly. For a few years the whole of it should retain your interest, because you are still more or less in search of your place in the world, and therefore you should be familiar with many lines of work. A monthly, too, which offers a more general view of the entire field of engineering is worth your while, for it tends to broaden and to attract attention to lines which may have permanent interest. Such magazines frequently contain valuable matter relating to shop management and accounting that is hard to find elsewhere. In course of time it is well to increase the number of technical papers and to restrict the reading more closely to the subjects of your special interest, but too early specialization is narrowing and harmful.

As soon as you have read the principal books relating to your particular subjects, take up other and more remotely related lines, but always follow a plan; for variety without it will lead to weakness. At the same time the plan should be subject to whatever alterations more mature judgment dictates. Avoid reading whatever comes to hand. No knowledge is worthless; but a small fund of well ordered information is much more serviceable than a larger amount of haphazard, ill-rounded, unrelated knowledge. It is difficult, but essential to the highest success, to be both broad and thorough, "to know something of everything and everything of something."

Do not read superficially nor accept all you read as the truth, solely because some writer has had the courage to put the matter into print. Engineers are not agreed upon all points, and many statements which are made as though they were generally accepted are open to question, sometimes in error. They must bear the test of reason. If they do not, there is something the matter with them or with your reasoning, and it is well to determine positively which is at fault.

Read descriptions of designs and of methods of construction, in order that you may have ready for use the results of other men's thought and experience. You should profit by their errors; and frequently a new application of a method or a slight improvement upon it will effect much. Each generation of engineers must begin where the preceding left off, if we are to make progress. Yet each year engineers waste much labor by re-inventing and re-devising what has already been well done; and much money is squandered in repeating er-

rors which should have taught a lesson, all through lack of familiarity with technical literature, or the lack of a library. Remember that progress is made by small increments and with much stumbling and many falls, rather than by spectacular leaps and bounds. Wonders are rarely found outside the columns of our sensation loving newspapers. And if you want to make all your strength and ability effective, do not ignore what other men have done, but employ their results honestly and freely as a basis for your own work. Acquire with the utmost dispatch and with much financial sacrifice, if need be, a well selected and comprehensive reference library. Obtain at least one good book upon each subject as early as possible; and buy the back numbers of the principal engineering journals and technical society transactions for a period of ten years or so previous to your graduation. You must be able to turn at need to the records of what has been done as well as to what other engineers are now doing, if you would save yourself labor and error. The field is not virgin and you are not pioneers. At the same time you must neither become a slave to precedent nor so fear falling into the errors of others that you fail to act on your own initiative. Only those who do nothing never make mistakes.

Immediately after graduation join the principal technical society in your own line, read the papers and discussions, and attend the meetings if possible. And as fast as your years and experience permit, move on to the higher grades of membership. This identifies you with your profession, places at your disposal the most advanced professional thought, acquaints you with the leaders among your professional brethren, and as soon as you are prepared to take part in the discussions, supplies the means for recording your own thought and aids you in establishing your own fame.

Read from the beginning all you can find relating to the lives and works of famous engineers. There is no greater source of inspiration, no more certain method of obtaining a well balanced understanding of the whole field of engineering, no surer way of gaining a knowledge of what qualities in men make for success. Much encouragement will be drawn from this source, and many a pitfall avoided.

Another neglected means of assistance is the miscellaneous papers prepared by professional men for the purpose of aiding the younger men to start aright and to pursue the best course. Addresses to graduating classes and papers relating to special engineering subjects frequently contain many valuable suggestions. Sometimes they are made available by publication in pamphlet form, in the technical press, or in book form. Dr. Humphreys, President of Stevens Institute of Technology, has published two volumes of papers written by him-

self and other prominent practitioners, many papers by Dr. Waddell and others have been presented in pamphlet form; and the engineering journals occasionally publish the important portions of able addresses and papers.

The public libraries in our larger cities are of material service in both technical and cultural lines. Their chief value lies in enabling you to examine books before purchasing them and in the reference books they possess. But it is well to remember that any book which is worth reading should be purchased, in order that it may be referred to or read again at pleasure; for no one can remember all he reads.

Supplementing the reading along purely technical lines, it is well to take up at a comparatively early period the sounder books relating to methods of accounting, shop and railway management, banking and finance, the laws of contracts, and the laws governing construction. A knowledge of all these subjects is absolutely essential to the engineer who reaches the top. Let me cite one or two cases in illustration. My firm was recently called upon to examine an important bridge, to report upon its condition, and to advise what would be the cost of a new single-track structure, the cost of a double-track structure, and the cost of a single-track superstructure supported on piers which would ultimately carry another single-track superstructure. The present traffic requires but a single-track, therefore it was also necessary to advise the client how soon the traffic must be sufficient to make a double-track structure necessary, in order to warrant the higher present cost of the second and third types of bridge, and how much of the cost in each case would be chargeable to maintenance and how much to improvements.

Some years since a railroad company by which I was employed was obliged to renew the superstructures of two bridges over the Ohio River. Navigation interests demanded wider channels than the old bridges provided; and before the War Department would grant permission to build new superstructures on the old piers, without increase of span length, it was necessary for me to prepare a statement showing what present payment the United States must make in order to compensate the railroad company for the increase in first cost of the larger span in one bridge and of a cantilever structure in the other, and for the increase in the cost of maintaining, and ultimately of renewing, the more expensive structures.

Such statements as these require for their preparation a sound knowledge of accounting, of funding, and of maintenance charges. Yet they are less complicated than many statements the engineers for manufacturers find it necessary to make.

The knowledge gained by all the reading we have considered is rendered much more available if the library be well indexed. There is a general index of engineering literature which should be purchased early; an excellent index of current technical periodicals appears in the *Proceedings* of the American Society of Civil Engineers; and the engineering papers provide an index for each volume; but it is advantageous for every engineer to make a special index of his own library, including everything but the handbooks; for there are many valuable pamphlets and documents which are not mentioned in any published index; and the making of an index not only classifies one's knowledge and saves much valuable time, but it teaches the method and the system which govern in all large organizations. Indexing is something of an art and merits careful study, therefore I would call attention to two good articles on the subject which are to be found in the earlier 1907 numbers of *Technical Literature.* As you reach a higher professional position, the increase in the size and scope of your library and the greater demands upon your time make it essential for you to leave the indexing to assistants; but you will always find it advantageous to keep in close touch with the work.

It is advisable to go through your library from time to time and weed out antiquated material. Do not let the possession of an old edition of a book keep you from purchasing a more recent one, but make sure that the new edition is altered in more than the title; for publishers often make new editions on account of very trivial revisions. Watch the reviews for criticisms of new books and buy promptly whatever seems valuable to you. The profession is making rapid progress, and books get out of date very quickly; therefore you must never cease to purchase new books, if your library is to keep pace with current practice. Collect the bulletins of the Geological Survey and the Bureau of Forestry, the Watertown Arsenal Reports, the Reports of the Chief of Engineers of the Army, and other government documents. They frequently contain much valuable information, and they may be had for the asking.

One reason why young engineers do not acquire a library is because technical books are expensive. But no condemnation can be too severe of an economy which has so large an influence against both immediate and ultimate success. Five hundred dollars will buy more technical books and periodicals than are possessed by most engineers who have been out of school from eight to ten years; in fact I doubt that the average young man spends thirty dollars a year for such purchases. I have known many an engineer who carried all his books about in his trunk and had plenty of room left for his clothes. How much would the knowledge gained from the study of books costing

one hundred dollars per annum increase the earning power of any young engineer? It will vary with the man and with his opportunities, but two or three times one hundred dollars a year is an absurdly low estimate for the earlier years, and ultimately the amount is not to be computed.

But I fear that in most instances economy is but a cloak for the true reason, viz., that the young man lacks the wisdom and the energy to continue to study. He thinks vaguely that in some easy way he will learn as he works for his living, that knowledge and position will come to him as an inheritance. They will not come so, but disappointment will, with absolute certainty.

The field of engineering has become so broad, and competition so severe, that no one can practice in many lines, as was customary twenty-five or thirty years since. The highest success is to be won only by making a specialty of one or two of the divisions of one branch of engineering. But the foundation should be broad. The young engineer should read one or two of the books relating to each subject, and, when he has chosen his specialty, buy and read all the other books which deal directly with his work. As before pointed out, if two or more books cover the same ground, each will present the points in some different way which improves the understanding of them and fixes them more firmly in the mind. But two books never cover precisely the same ground. Each lays special emphasis on one phase of the subject and presents it in a superior manner. Take bridges for instance. If you have studied Johnson, you will find in DuBois a superior chapter on erection; in Merriman a superior treatment of arches, suspension bridges, movable bridges, and cantilever structures; and in Burr a superior mathematical treatment of the elastic theory. Johnson, on the other hand, has superior chapters on mill building construction and upon the aesthetics of design. Again, Howe's book on arches, Wright's books on draw bridges, and Ketchum's books on mill buildings and on bins, specialize in those subjects and treat them much more fully than do the four broad texts first mentioned. You have not covered the general field properly until you have read these four principal books, and you have not covered the subjects of bridge superstructure design, and of steel building design which is almost inseparable from it, until you have studied the many special books dealing with particular branches of it; and, if you are taking up bridge work as a specialty, you have only begun when you have mastered these. You must yet study the metallurgy of iron and steel and the various other alloys of iron, the chemistry of paint, methods of fabrication, methods of testing and inspecting, the design and construction of foundations by the pneumatic, open dredging, and other processes, the construc-

tion of reinforced concrete bridges and floors, paving, lighting, the operation of signals, the various prime movers used to operate moveable bridges, shore protection, field work in connection with bridge construction, piles and pile driving, timber trestles, and creosoting and other methods of timber treatment. Will a thorough study of all these subjects make you a bridge engineer? Not at all. They constitute only the strictly technical phases of the subject. Specifications and contracts, organization and management of manufacturing plants and construction forces, business systems, contracting, accounting, and finance, are all subjects which the bridge engineer must study. In addition, if an engineer is to attain the highest professional position, he must be a man among men, must be a well read, cultured gentleman, able to meet on their own ground men in business and in other professions, and to make himself a power among them.

A similar broad and thorough preparation is essential for the practice of any other specialty. The engineer who turns his attention to the sale of machinery, electrical apparatus, steel work, or other engineering materials and equipment, must have a detailed and accurate technical knowledge of his specialty and a broad view of the general field, must know much of business and finance, and must have all the culture, tact, and finesse of a diplomat as well. The large and growing field of technical journalism demands men of the highest calibre, men who are sound in their fundamental knowledge of many lines and so familiar with good practice that they may write with authority on many very different subjects. We have only to look over the back numbers of the technical papers to see what advances in this branch of the engineering profession have been made in a few years; while acquaintance with any good paper will show that the technical journalist must have an exceedingly broad view of a large field and yet must be exceptionally sound, if the pitfalls of hastily written leaders and false theory are to be avoided.

Substantially all the officers of many of the large companies engaged in manufacturing, construction, and transportation have been chosen from the engineering staff; and the time is not far distant when railroading, mining, all mechanical lines of business, and all construction work will be in the hands of the technically educated engineer. The material progress of the world is dependent upon him. It is true that he is not sufficient unto himself. He is a practical man and employs in his work whatever knowledge and material he can obtain from others. He uses freely the discoveries of the mathematician, the chemist, and the physicist; the material resources of the earth; and the fruits of the skill and labor of the farmer, the artisan, and the ordinary

workman. But he is chiefly responsible for the material progress and for much of the intellectual progress of the human race.

The field is broad, the compensation is large, and the possibilities are unlimited. Will you take advantage of them? Will you employ all your strength, all your energy, all your ability to meet every requirement for the highest order of success? Or do you prefer a life of ease and obscurity? It is for you to determine. Your fate is in your own hands.

THE EDUCATIONAL VALUE OF THE TECHNICAL PRESS WITH SPECIAL REFERENCE TO ENGINEERING NEWS.

By

Harwood Frost, B. A. Sc.

Some readers may claim, perhaps with a certain amount of justice, that this paper is in the nature of an advertisement for an engineering journal, as its author was the Secretary of Engineering News; nevertheless all the statements in it are correct, and the advice which it offers engineering students is good and sound. The Editors can do nothing but say "amen" to Mr. Frost's remarks and express the hope that their readers may profit by his words of wisdom.

As is evidenced by the numerous asterisks employed, a large portion of the address has been omitted. This does not mean that the deleted parts are in any way objectionable, but simply that they are not pertinent to the objects of this compilation of addresses.

Mr. Frost was born at Smith's Falls, Canada, in 1872, and received his early education there and at Plainfield, N. J. In 1893 he graduated at Lehigh University with the degree of M. E., and in 1895 he took at McGill University the degree of B. A. Sc.

He began his professional practice at Smith's Falls with the Frost and Wood Manufacturers of Agricultural Implements, and in 1899 he went to Europe, where he represented that firm from 1901 to 1904.

From 1905 to 1910 he was with Engineering News, at New York City, and in 1911 he purchased an interest in the Brown Portable Elevator Company and became President thereof.

Mr. Frost is the author of a number of valuable papers and of two books, "The Art of Roadmaking" published in 1910 by the Engineering News Publishing Co., and "Good Engineering Literature," published by himself in 1911. This last work is one that every ambitious student of engineering should read and study.

Editors.

THE EDUCATIONAL VALUE OF THE TECHNICAL PRESS.

By

Harwood Frost, B. A. Sc.

This subject is one of great importance to every engineering student and every practicing engineer. It is a subject with which the staff of every high-class engineering journal is brought into close touch and it is in connection with this that I wish to address you, in an effort to explain something of the many forms of engineering literature, of its production, and of its educational value and its necessity in the work of the engineer.

Under the general title of "The Technical Press" may be included, not only periodic literature, but also books, trade publications of a certain kind, and pamphlets, bulletins, and proceedings issued by engineering societies, by the government departments, and by individuals. The term is a broad one; too broad, in fact, to discuss satisfactorily on this occasion, hence I shall confine myself to technical books and periodicals. The other elements of the technical press, have, in many cases, a considerable educational value, but trade publications and government bulletins can generally be obtained for the asking, or for a few cents, and are not looked on with the same respect as the periodical or book for which you have paid out several dollars of your hard-earned cash. This is the class of literature with which you will be brought in close contact throughout your professional career, and to get the best value for your money, there is need of careful consideration in your purchases.

The "Technical Press,"—using the term to represent book and periodic literature—must be considered in itself an educational institution. It is a school in which not only the professor and the student study together, but also the men in active practice, ranging from the green graduate, trying to hold down his first job, to the old fellows, the Nestors of the profession, full of years and honors, but it is a fact, that in spite of their years and honors and their bank accounts, however large they may be, they never reach that point in their professional careers where they feel that they can do without the instruction supplied by the technical press.

Do not make the mistake of allowing yourselves to think that your graduation from this school has made you "Engineers." Your instructors have laid good foundations: they have set up the piers, but the

superstructures must yet be built, and in that every man is his own architect. Your graduation simply means your entrance into a broader field of activity in which you will be brought face to face with the real problems of life, and if you decide to follow out your line of studies and take up the profession and practice of engineering, you will find that your success will, in a large measure, depend on the use you make of the literature of your profession.

You have probably been told often that experience is the greatest teacher and the best school, but while it certainly is one that every one of you will have to go through, sooner or later, no man ever achieved great success who depended solely on his own experience for enlightenment. The technical press records for your benefit the experience of others, and it is on this experience that you must depend principally for the building of the superstructure of your professional career.

In referring to the technical press as an educational institution, I do not wish to imply that it should be considered as a substitute for the college. The high-class technical journal does not attempt to give you an elementary education, or to duplicate what you have already learned or are supposed to have learned in college. It excludes from its columns nearly all matter of an elementary nature and such material as may be found in standard text-books or which is already a matter of common knowledge to the profession. It seeks for the benefit of its readers the sort of information that is not yet found in text-books nor taught in the class room. Wherever a man is doing work in a new or better way than others; wherever new and better tools are made, or new processes devised; wherever progress is being achieved, it is the province of the technical press to investigate that progress and to make it public for the general benefit.

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Two generations ago, engineering literature, as we know it, was practically non-existent; today, there are several hundred weekly and monthly technical publications; there are hundreds of engineering societies of all grades, from the great national organizations to the local societies in towns and colleges, many of which publish periodic proceedings containing the papers and discussions presented at their meetings. Add to this the avalanche of new books on engineering subjects that is being poured forth by the various publishing houses; add further, the thousands of trade publications issued by manufacturing concerns, many of which are real engineering treatises; add again the vast volume of technical literature published by the Government in the form of specialized bulletins, and then consider that this overwhelming flood of literature is the production of America alone and that England, France, Germany, Italy, Spain, and even Russia and Japan, are also pro-

ducing literature in greater or less quantities. Consider all this, and you will see what a problem is presented in this huge bulk of printed material, and will realize how true it is that "Of the making of many books there is no end."

No man can read all this literature; no, not the tenth part of it, even were he to do absolutely nothing else. If you select any specialized subject, such as "Road-making," how many titles are there? You might say a dozen, or two dozen. In making up a reference bibliography of this subject recently, selecting only the works of historical and practical value and discarding the many pamphlets and government documents of little or no permanent value, and omitting all trade publications, I compiled a list of nearly 500 titles in the English language alone, and this subject does not approach in volume some others, such as Structural Engineering and the Building Trades, for instance. This list, however, covered the period from 1600 to 1910 and of these 15 were issued in the seventeenth century; 50 in the eighteenth century; 250 in the nineteenth century, and 150 in the first ten years of the present century. What it will be before the year 2000, is beyond calculation.

Some of these books attempted to treat the subject in an encyclopedic manner, such as Byrne's 1000-page "Treatise on Highway Construction"; others specialize in some one or two features of the subject, such as Soper's "Modern Methods of Street Cleaning" and Judson's "Dust Prevention." When you consider this large volume of literature, you wonder what becomes of it, and who reads it all. As I said, no man can read it all, and no man in his right senses would or should want to do so.

There are not only many books, but there are also many kinds of books. There are books describing good engineering practice, but poorly written, and there are books that are good literature, but bad practice. There are books, excellently written, perhaps, but based on wrong theories or advocating the authors' personal fads. So, also, there are many kinds of writers and many ways of writing books. There is the "hack" writer who will produce a book on any subject, of any length, in almost any given time. His method is to accumulate a quantity of printed material on the subject, from any source, and rehash it into readable shape, and to the desired quantity. He may, or may not know anything of the subject of which he writes, but he assumes that what has already been written by those who do know, and published by those who are supposed to discriminate, is good enough for his purposes. Such books contribute nothing to our store of technical information; they are often misleading and unreliable, but their production is cheap,

and a sufficient number can always be sold through modern advertising methods to yield a profit to both publisher and writer.

In contrast to this there is the more careful compiler, the man of literary ability and breadth of mind, who studies his subject, collects his material from recognized authorities and with good judgment of the value of the literary productions of others, selects the good from the bad and produces an evenly balanced and smoothly reading treatise. This book also, may add little or nothing to existing knowledge, but it places the best of that knowledge in easily accessible form and constitutes a welcome addition to our library. Then there is the treatise prepared by an engineer of wide experience which may be a valuable record of achievements, but written in a style about as readable as the patent office Gazette or the Census Report, while another writer may present practically the same facts in a style as readable as a book of fiction. There are also the rare and occasional books that may be referred to as the "classics" of the engineering profession. They are the results of years of careful and patient research, compilation, and selection by men of exceptional education and experience.

In this class may be mentioned Trautwine's "Civil Engineer's Pocket-book" familiarly known as "Trautwine," of which nearly 100,000 copies have been sold; Wellington's "Economic Theory of the Location of Railways," generally known as "Wellington"—a book now 23 years old, but still a standard, almost beyond competition, although in some parts rather obsolete.

Besides these, there are books padded with many useless words and facts, books with a scarcity of facts, books with a greatly mistaken or exaggerated idea of the importance of their subjects, and many other varieties, too numerous to mention.

Seldom, however, in technical literature, is an entire book the original production of one man. Individuals usually give the first descriptions of their works or results of their investigations in the form of contributions to periodicals or of papers read before engineering societies, and when such material has become more or less voluminous, someone undertakes to collect it, sift it, re-write and arrange it for publication in book form. If the book is to be a success, this work of preparation is a laborious matter and cannot be done in a slipshod or careless way. First and foremost, perhaps, the writer must be thoroughly interested in the subject and feel an impulse to write on it; he must be moved by a desire to contribute something to the world's store of knowledge and to fill a gap in existing literature, rather than by a desire to produce merely a commercial article for the sake of the royalties resulting from its sale. In the writing of the book many things must be considered. A mere statement of facts does not constitute a book. The

facts must be presented in logical order and in brief and grammatical language that can convey but one meaning. Pet theories and fads must be forgotten and illustrations should be used wherever necessary to assist the reader in forming a clear and concise understanding of the text and not for the purpose of padding a slimly worded book up to a three dollar size.

After the manuscript is prepared, the book must be manufactured and marketed through a publisher, and I think that I am justified from an experience of some years in saying, without going into details, that there are several kinds of publishers, from the factory that turns out "hack" literature to the publisher whose name is a guarantee of authority and reliability.

From this somewhat superficial classification of books, writers, and publishers, you can readily appreciate the necessity of most careful selection. Technical books range in price from $1.00 up, principally up, and you can spend a big pile of money on a small pile of books. Therefore, when you buy, buy with care. Few engineers know what they really want in the way of books. Some buy nearly everything in their line of interest, good and bad alike, but the average engineer can afford only a few books on any one subject. He wants only the best, and in many cases he is not so located that he can examine the books before buying. He usually buys from the advertised descriptions, depending entirely on the reputation of the publishers or of the writer, but he is taking a leap in the dark that may be costly, as even the publisher with an A-1 reputation may not be infallible. I recollect an occasion when I was looking over the library of a well known bridge engineer and on my remarking the omission of several books on his specialty, he opened a drawer of his desk and showed me quite a number of books, some issued by the best known publishers, which he had purposely concealed from his assistants because of their absolute untrustworthiness. The publisher does not, and cannot afford to produce a book with intention to mislead, but through a mistaken judgment of his advisers, or through the pursuasive ability of a writer, he is sometimes induced, even against his better judgment, to issue a work which later proves to be unreliable. Such a book not only brings financial loss to the publisher, but in the hands of an inexperienced man may become a source of great danger, resulting in disaster and a ruined reputation.

You will ask: "How, then, are we to know what books to buy?" That is a serious question with all engineers, young and old. The reviews of books published in the recognized engineering journals, generally speaking, form a good guide, but like the books themselves, there are various kinds of book reviews. The average "review" of a technical book is a rehash of the author's preface, and knowing this, some

authors make broad statements of what their books are or are supposed to be, and thus obtain good notices, with their consequent sales. The periodicals that actually review or criticize technical books in an intelligent manner, are comparatively few.

The "Book Review Digest," a guide for librarians, published in Minneapolis, has selected only four periodicals out of the hundreds in the technical field from which to quote book criticisms. These are "Engineering News," "Engineering Record," and "The Engineering Digest," and for electrical books only, the "Electrical World."

I believe that I can fairly say that the book reviews, published in the monthly Literature Supplement of Engineering News form as good a guide to the selection of engineering books as is available to engineers today. In these reviews, all books are judged by the standard of their usefulness to the practicing engineer, and the policy is very strict. Practical engineers, who are recognized authorities in their various fields, are selected as reviewers; the criticisms are fair and no favors are shown to either publisher or writer; no consideration is made as to whether or not the publisher is an advertiser, and no money could buy a favorable notice for an unworthy book. Many copies of Engineering News are purchased for the sake of these reviews alone, and there are many engineers who will not purchase new books on important subjects until they have seen reviews in Engineering News. The same policy is adherred to in the case of individual opinions. When a letter is received asking for an opinion as to the best books on a certain subject, or for a comparison of two or more books, it receives careful consideration, on the basis that it is better to keep a man's good-will even at a considerable expense, than to lose that good-will by selling what may be entirely unsuitable for his purposes just to make a sale. Hundreds of inquiries of this nature are received every month and that this policy pays is shown in the fact that we are dealing today with engineers in every corner of the world—men whom we have never seen and never expect to see, but who trust entirely to our selection and judgment.

Another point of importance is the necessity of being up-to-date in your technical reading. The necessity of the publishers keeping his literature up-to-date is one of the main reasons for the vast number of books that are published. Engineering practice is so constantly changing that it needs many books to keep pace with it, and most of them must be new books, but the best of these run through several editions and remain standard for some years. In regard to new editions, however, it is well to be careful. The 47th "new and revised" edition of Wood's "Treatise on Railroads," or some other such book, might be an interesting piece of literature and it might also be a most comprehensive work, but it would have the fault common to all books that have run

through a large number of "revised" editions—a foundation based on out-of-date principles. It is difficult, if not impossible, so to "revise and enlarge" any book through many editions, that it will be as thoroughly up to the times as another and entirely new book, written with the most modern conditions as a basis; and the time must surely come when the old reliable treatise, like the defeated champion, must be dropped into the regions of the "has-beens."

To illustrate this, referring again to the subject of "Roadmaking," in 1583, there was published a book entitled: "The Duties of Constables and Surveyors of Highways." It ran through seven editions in 25 years, but the art advanced, and in 1610 was issued a new book entitled: "A Profitable Work Concerning the Mending of Highways." This preached a new doctrine—that of highway repairs. Then came various books telling how to make these repairs; later MacAdam, Telford, and Metcalf came on the scene and propounded new theories of construction which called for many more books and pamphlets. Later followed the invention of the stone crusher, the steam roller, the road machine, mechanical excavators and other machinery for road construction; a great variety of mechanical devices for street cleaning; a variety of paving and road-making materials, and finally the automobile with its accompanying dust problem. All these call for special treatment and cause the production of literature in the proportions of an inverted pyramid. Pages might be quoted from many technical books published within the last ten years to show of how little value much of this literature is today, and the uselessness of out-of-date engineering books, but I will only quote one sentence from the aforementioned Wood's "Practical Treatise on Railroads," the standard of 1825, in which the author seriously states that "Nothing can do more harm to the adoption of railroads, than the promulgation of such nonsense as that we shall see locomotive engines traveling at the rate of 12, 16, 18 and 20 miles per hour." Recent books on the subject of flying machines and some other subjects become out-of-date in many of their statements almost before they are off the press.

This is sufficient, I think, to show you the importance of keeping up-to-date in your reading, and of keeping pace with new developments in that field of engineering in which your interests lie.

As to the extent to which you should keep pace with these new developments, let me quote from an address by Mr. C. W. Baker, Chief Editor of Engineering News, before the students of the University of Michigan.

"Take, for example, that branch of engineering known as Water Power Development. We do not have to go back more than 40 years to reach the time when the old 'mill-rights' were the men who act-

ually did all the work that was done in this country in the development of water-power. All the knowledge they needed was carried under their hats, with perhaps some few rules copied in a private note-book. Today, however, an engineer who conducts a water-power development enterprise must, either directly or through assistants, be familiar with the latest practice in stream gaging, dam construction, hydraulic motors and regulators, electric generation, transmission and utilization, and power-house construction, to say nothing of such matters as the relation between engineers and contractors, executive methods, dealings with labor organizations, franchises, and riparian rights. It may be well, also, for him to know how to handle a board of directors and float a bond issue.

"Perhaps you may object that no one engineer can do all this, but the fact is that engineers, in the aggregate, are doing all these things; and that every successful engineer today finds himself constantly in need of knowledge that he cannot carry in his head and for which he must rely on the experience of others, as recorded in professional literature."

This brings up to the engineer the problem of digging out of the mass of literature offered him the things which he wants and needs; and it puts up to the makers of this literature the problem of how to turn out their product in usable form; how to give the engineer what he needs and give it to him in such shape that he can make practical use of it.

In a general way, it would appear that the solution of this problem lies in the direction of specialization. This is an age of specialization. In law the lines of specialism are drawn very fine and there is hardly a lawyer whose field of activity is not well fenced in, and in medicine, the all-around family doctor of a generation ago has given way to a hundred or more specialists. In the engineering profession specialization is almost as extensive, but it is a thing more recent than we are apt to realize. The only real engineering work done a century ago was in the construction of canals. The profession naturally developed with the growth of the country along more or less distinct lines, but its formal differentiation into the four great main branches of Civil, Mechanical, Electrical, and Mining has taken place within a quarter of a century. Today each of these great divisions is sub-divided many times and each of these sub-divisions has its own special literature.

To the uninitiated, it might appear that an engineer does not have to read the whole vast mass of the literature of his profession, but only that relating to his own specialty. Actually, however, the problem does not work out so easily. There are no tight fences built between the different specialties, and he would be a foolish man who would build such

a fence around himself and limit his view of life to what he could see in one direction through a little peep-hole. On the contrary, the boundaries overlap on every side. Here is an engineer, let us say, of a Portland cement works, interested in the use of cement in buildings, bridges, dams, and a hundred other structures, and also in the appliances of the mine and the quarry, in steam-shovels, kilns, hoisting and conveying machinery, and in the conveying of materials. Manifestly, then, this engineer wants something more than the literature of Portland cement manufacture.

Another reason why an engineer cannot wisely make his reading of too limited scope lies in the fact that in all construction work the engineer is constantly working himself out of a job, and every change presents new problems of its own for solution. You will readily understand, therefore, why the question of a too voluminous engineering literature cannot be disposed of simply by saying that each engineer shall read the literature of his own special branch. If he is wise and ambitious, he will read that and much more.

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There is a very considerable amount of engineering literature that assumes to itself an air of superiority because of the fact that it is of no use whatever, such as the theoretical discussions and records of experimental research which wander so far away from the practical worker that he can never make any use of the results.

When you make a critical analysis of engineering literature, measuring it all by the standard just stated, you will be surprised to find what a large portion of space in some engineering journals and society transactions is taken up with such matter, which nobody ever used and nobody ever will use.

There seems to be an idea among a certain class, that the thing which is directly useful has a plebeian odor about it, while useless knowledge has something of the same odor of sanctity that clings around the old classical studies. So in the application of science, theory is too often set on a pedestal, and elaborate researches are carried on to search out facts which, when they are found, are of no earthly use to anyone.

Theory is all right in its place, aimed straight at practical results, but vague theorizing and experimenting, with nothing more in view than a hazy possibility that somebody, sometime, somewhere, may find it useful, only cumbers our already overcrowded literature with useless stuff, and occupies the space needed for things of greater importance.

Another sort of literature which, at the present day, ought to be scrutinized very carefully, is—descriptions of engineering works. It may seem strange to you that descriptions of engineering work should not have the first place. There was a time, not many years ago, when

engineering journals consisted almost wholly of such material, but no journal could today attempt to publish descriptions of every engineering work—every bridge and water-works and steam-engine or mine or power station, and so on throughout the whole range of activity of a thousand busy engineers. Such descriptive matter would answer no good purpose, and, in fact, would be the least useful. You will find that the engineering journals and society transactions in which this class of articles consumes a large portion of the space are left to accumulate unread upon the shelves, or find a final resting place in the waste-basket.

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Every engineer wants to keep in touch with everything of importance that is published, affecting his interests; but such material may be published in any one of a hundred or more periodicals and no man can attempt to read them all, even if he could afford to buy them. The best, and practically the only, method of getting this information, that is open to the busy engineer, is through the use of an index, such as the "Technical Press Index," published in connection with "Industrial Engineering and The Engineering Digest." This gives each month all details and brief summaries of about 500 important articles published during the preceding month, and by using this as a supplement to his reading of two or three of the leading periodicals in his field, an engineer will have at his command everything of special interest to him.

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In conclusion, I believe that it would pay everyone of you to read Engineering News—not to look it over superficially in the library, but to subscribe for it, to receive a personal copy, to study it weekly as received, and to have your copies bound and carefully preserved for future reference. We have reason to believe that most of our subscribers preserve and bind their copies of Engineering News, and while from one point of view it is of no interest to us what becomes of our issues after they reach the subscribers, in pursuance of our purpose to make the journal of the greatest usefulness to the engineering profession, we would strongly advise our readers to preserve their files complete.

We are aware that some of our readers pursue the practice of cutting from the paper such articles as are in their special line of work at the time, which they file on some system or other, and throw away the rest of the paper. Perhaps if a man were absolutely sure that he would follow a particular specialty all his life long and would never have need of information on any other department of engineering work, this would be a good course to pursue; but very few engineers can map out their future in that way. Not many years ago, thousands of engineers were devoting all their attention to railroad construction; today nine-

tenths of them are in reinforced concrete work, hydro-electric development, contracting, and other fields of engineering work, and it is quite safe to say that those fared the best in making the change who were the best equipped for the other lines of work and who had kept in touch with them so far as possible during their work on railroad construction.

The men who have achieved the greatest measure of success are the men who have worked, read, and thought more than was absolutely necessary, who have not been content with knowledge sufficient for the present needs, but who have sought additional knowledge and stored it away for the emergency reserve.

It is this apparently superflous labor that equips a man for everything that counts in life; and I would, therefore, advise you, in your own interests, to preserve and bind your files of Engineering News. The possessor of these files and the periodic indexes that have been issued will have at hand an encyclopedia of modern engineering progress which will be almost as easy of reference as a dictionary and which will constitute in itself a complete library of engineering literature. The time will come when the information you can find in these pages on other departments of engineering than that upon which you may be at any one time engaged, will be of the greatest value, and you will find that your subscription must not be considered as an expense—it is an investment that will repay you many times over.

BUSINESS TRAINING FOR THE ENGINEER.

By

Dr. Alex. C. Humphreys.

Dr. Humphreys, the President of Stevens Institute of Technology. is also a practicing engineer of high standing who has been so successful from a business point of view, that he has come to be acknowledged as the highest authority on the question of providing business courses in technical schools. As an engineer to be truly successful must be a good business man, it behooves the student of engineering to read all he can about the business features of engineering practice. Therefore the numerous books and papers of Dr. Humphreys that contain references to this subject are commended to our readers for perusal. Most of them can be obtained through the Secretary of Stevens Institute of Technology, Hoboken, N. J.

Dr Humphreys was born in Scotland and came to America at the age of eight. He was educated at his father's private school in Boston, and at the age of fourteen he passed an examination for entrance into the U. S. Naval Academy, but was disqualified on account of youth. Then he went into business, first in Boston and afterwards in New York, rising steadily for ten years. At the age of twenty-four he recognized the necessity for a technical education and began the full regular course at the Stevens Institute, attending lectures twice a week and doing the rest of the work at home. In due time he graduated, and shortly afterwards he accepted the office of Chief Engineer of the Pintsch Lighting Company. His work since then has been mainly in the line of gas engineering, in which he is recognized very generally as the highest authority.

In 1902 he was elected President of Stevens Institute, and it is owing to his good work that that school has been so successful in Mechanical Engineering education. Dr. Humphreys is a D. Sc. of the University of Pennsylvania and an LL. D. of Columbia, Princeton, and New York Universities. He is a member of the leading engineering societies of America and England, besides many other societies working in public interest.

Editors.

BUSINESS TRAINING FOR THE ENGINEER.

By

Dr. Alex. C. Humphreys.

Self-evident should be the truth of the proposition that the engineer ought to be a man of business, or at least, informed of, and prepared to conform to, business conditions and business methods. When this proposition is squarely laid before them, it is self-evident to the majority of successful engineers and men of business. Business men, bankers, and manufacturers not infrequently refuse their confidence to engineers and experts as a class, because, under trial, some individuals have demonstrated their incapacity to meet business conditions; from the standpoint of the man of business their reports, advice, conclusions have required interpretation and readjustment or amendment.

The man, so far somewhat exceptional, who is able to bring to the service of his clients or associates a sound technical training and the ability to meet business conditions, proves by his comparative success the material value of this dual capacity. For the sake of the profession and the country at large it is important that this broader capacity should no longer be exceptional.

To this end the professional educator and the engineer-student must better recognize the conditions to be met in practice. A general and definite demand on the part of the business world for engineers of such broader capacity would ensure the necessary reform in the separate schools of engineering and the university departments of applied science. All that is possible should be done in the technical schools to harmonize theory and practice.

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After graduation the young engineer will be influenced by commercial conditions, and perhaps by his own natural bent, to become a specialist. Today the field of engineering is so wide and the requirements are so exacting that no man can expect to excel unless he confines himself within certain rather narrow limits. But no matter to what part of the field he confines his efforts, he will surely find himself limited and bound, more or less by commercial conditions.

From this it may be argued that the engineer should not aim to be also the commercial manager; as a specialist, he should confine himself to the engineering branch of his business. To this it may be replied that whatever special branch of industry is adopted, the engineer

must understand and practice in harmony with the commercial conditions of that specialty. There may be a further specialization between the engineering and the commercial management, but the engineer should have at least a knowledge of the general fundamentals of business practice and also a knowledge of the special limitations attaching to the particular business pursued.

As in schools of engineering we cannot expect to instruct the students in all the specializations of engineering science and practice, so with instruction in business methods we can expect to give only a broad training in fundamentals upon which the student can safely and expeditiously build when the need for specialization is encountered.

If it be admitted that the engineer-student should receive some instruction in business methods before graduation, it then remains to be determined what can be added in this connection to a course already crowded almost to the limit. Perhaps the matter of first importance is accounting. We cannot expect to train the students to be expert bookkeepers, nor is it necessary to do so; but we can expect to give them what is of more value and what many bookkeepers do not possess—a sound knowledge of the principles of double-entry bookkeeping. This knowledge engineers need to enable them to exercise a close, intelligent, and independent supervision of manufacturing cost.

The students should be taught carefully and conscientiously to discriminate between the charges to capital or revenue, and they should be warned of the ease with which errors can be made in this connection and the disastrous consequences likely to follow their commission. They should also be shown the necessity for making adequate provision for depreciation of plant, the scheme to be based upon an exhaustive analysis of local conditions and not upon the blind acceptance of arbitrary rules formulated by accountants. They should be shown that books can be so kept, either through ignorance or design, as to hide the facts and to present a warrant for the payment of dividends unearned. They should be shown that all this, and much more, they will need if they are to be competent as managers or reliable as advisors in connection with the purchase of properties.

They can also be shown that often, when called in to pronounce on the value of some new apparatus or process where these have already been under commercial test, the technical investigation may well be supplemented by a competent examination of the books of account; and that here the man who is only an engineer or only an accountant will probably be found incapable of conducting such an examination. In such a course might also well be included enough instruction in the science of statistics to warn the student against the danger of drawing conclusions from insufficient or inconsistent data.

In connection with the work in this and other departments the effort should be made to bring the students to a keener appreciation of the value of a working command of English. They should be shown that it is not enough that they possess the knowledge, but they must have the ability to convey to others, and especially to their clients, in language concise and free from ambiguity, the results of their professional or administrative work.

Unquestionably there is a crying need for more efficient work in the teaching of English in the schools of technology, and perhaps this statement may fairly be extended to include some of the colleges and universities. Reform in this direction is most difficult of accomplishment. The work performed is too often of a perfunctory character, whereas it should be characterized by enthusiasm and originality. The time available is limited, and, therefore, the first care should be to give such a training in English as will be most efficient to meet the requirements of professional practice.

This leads naturally to another feature which may well be included in the department of business methods—instruction in the law of contracts. We cannot expect to give engineer-students a working knowledge of the law of contracts, but we may very reasonably expect to impress them with the dangers to be encountered and the necessity of knowing when it is advisable to seek thoroughly competent legal advice. Some advice in this line can also, to advantage, be included in the lectures on engineering practice.

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Generally the entering class in their wisdom are ready promptly to denounce as useless or out of place all non-technical studies; thus the sympathetic co-operation of the students, which is such an important element in the efficient teaching required in a full course of study, is not obtained, and the foundation is laid for many regrets to be experienced in the years after graduation.

RECORDS.

A Talk for Undergraduate Students of Engineering.

By

E. E. Howard, C. E.

This lecture, which was delivered in 1909 to the Engineering Society of the University of Kansas, is on a subject new to engineering students, but at the same time of great importance,—and not to them only, but also to engineers in general. Mr. Howard handles the question in a masterly manner, and his discourse is of an unusually pleasing character, imbued as it is throughout with a fine sense of humor. The Editors believe that their readers will peruse the paper with both interest and profit, and that they certainly will occasionally be amused by some of the author's illustrative stories.

Ernest Emmanuel Howard was born at Toronto, Canada, February 29, 1880, and was graduated at the University of Texas in 1900, with the degrees of B. S. and C. E. Immediately after graduation he was engaged in irrigation works for rice lands in lower Louisiana, afterward returning to the University of Texas as instructor in Engineering, and spending some time working for the railroad commission of that state under Mr. R. A. Thompson, its chief engineer.

In June, 1901, he entered the office of Dr. Waddell, Consulting Bridge Engineer, at Kansas City, Mo., and rose rapidly in his employ, in which he has remained continuously ever since. After some office work he was made Assistant Engineer on the construction of the Red River bridge at Alexandria, La., till its completion in 1902, after which he returned to the office for a year, then went to Mexico as Assistant Engineer on the extensive bridge work of the Vera Cruz and Pacific Railway, becoming Resident Engineer in Charge in September, 1903, which position he retained until the completion of the entire work in 1904. Next he took charge of the construction of the James St. Bridge and the reconstruction of the Ohio St. Bridge, both over the Kaw River in Kansas City, Mo.; and from March, 1905, till its completion he was in charge of the construction of the Sixth Street Inter-city Viaduct at Kansas City, a structure costing some $3,000,000.00.

When the firm of Waddell & Harrington was formed in January, 1907, Mr. Howard became the Principal Assistant Engineer; and in

September, 1910, he was made Associate Engineer. During the five years of the firm's existence, Mr. Howard has taken an active and responsible part in the designing and construction of over $10,000,000.00 worth of bridge work, and he is now doing his share in the handling of some $15,000,000.00 worth of structures, on the engineering of which the firm is engaged.

His personal work has covered every detail in bridge engineering of every kind, from the conception of projects to their materialization and the finishing of the structures; also examinations and reports upon old bridges, and aiding in the evolution of new and improved types of movable spans. Probably there is no engineer of his age in America who has had a broader or more extended experience than Mr. Howard; for at the time of this writing he is not yet thirty-two years of age.

He has contributed one extensive paper to the American Society of Civil Engineers, and has taken active part in other engineering organizations.

Editors.

RECORDS.

A Talk for Undergraduate Students of Engineering.

By

E. E. Howard, C. E.

Throughout the ages man has devoted much laborious effort to the making of records. Centuries before Job lamented "Oh that my words were now written, oh that they were printed in a book, that they were graven with an iron pen and lead in the rock forever," other men had been stirred with that same universal desire and by their efforts and with their genius had developed an art of record making. Some time ago an archæologist showed to me a piece of stone on which he said was the oldest known attempt of man to write, and the writing was done regularly, in well defined characters, skillfully cut on the smooth, rounded surface of a vase. Clearly it was no first attempt, but was a product of skill and practice so that one wondered, as he meditated, who before had trained and developed that skilled hand. From such ancient times down to this present, man has never ceased to make records, and today he is making more than ever before.

Every calling, every profession, every art, every science, every business, every industry of mankind has its records and its record-makers. It is not surprising that in engineering, a Science and an Art, a Profession and a Business, an Industry and an Inspiration, there are records to be made of many different kinds. When an engineer prepares a design, estimates, plans, and specifications, as a banker he has used records of money, as a merchant records of prices, as a statistician records of costs, as a transporter records of tariffs, as a producer records of materials, as a manufacturer records of products, as a lawyer records of legislation, as a physician records of human endurance, as an artist records of fitness, as a historian records of achievements, and as a poet records of his own imagination.

To come into contact with the record making of his chosen profession it is not necessary for a young engineer to wait till some one calls on him for advice as to building a bridge, or a dam, or a railroad; for with his first engineering undertaking record-making will be required of him. In fact, it is usually because of his record-making that the engineer-graduate has immediate market value.

Records are made for information, to preserve and to convey thoughts; and it is so axiomatic as to be almost unnecessary to say that the meaning of a record should be clear and plain. If a record conveys no meaning, it is no true record; if it conveys inaccurate meaning, it is a record worse than valueless. If a thought be worthy of preservation and transmission, it were a foolish thing to try to preserve it or transmit it in some unintelligible manner. Even when records are for ourselves alone, it is essential that they be decipherable. The first principle, then is

"RECORDS ARE FOR INFORMATION."

From marking numbers on stakes to the successive steps in the solution of complicated and abstruse problems, the larger part of the records you will make in the next five or ten years, will be made, as many good things are, by hand. Your value will be determined in no small part by your skill at this record-making and your skill will be determined in no small part by your writing and your figuring. Can you write? That is, can you write a page that you are not ashamed of? Can you write down a column of figures that you ought not to be ashamed of?

Long ago you began to learn to write, *but can you write?* Writing is good writing when it is legible, be it Spencerian, vertical, backhand, lean-over, or what not. Writing is bad writing when it is not legible be it ever so beautiful a piece of pen-and-ink hand-decoration. To be sure, great and honorable men are not always good penmen; but here is an immutable fact which you can accept now or learn later by experience: *legible and orderly writing and figuring will advance you in the estimation of everyone with whom you have to do business.* You can verify that statement even now by your own observations. You can see about you men whose ability was brought to notice by skill in this elementary art, usually considered mastered and done with long before college days. Of course, when you are Chief Engineer or General Manager with your name engraved at the top of the sheet, you will have a stenographer and will dictate all your letters; and then the merest scrawl or scratch over your title will serve to reveal to admiring and criticising henchmen your identity. But, between then and now there will be a space when, perhaps, you will be sending in monthly reports to the Division Engineer, and it will not count to your advantage if he has to write to ask you whether such a mark is intended to be a three or a five or some part of a mysterious secret code. Writing in itself does not make a man or an engineer; its character is no conclusive proof of a man's characteristics. Some of the best looking esti-

mates I ever saw contained the most errors; sometimes the most legible writing has the largest number of misspelled words; but if you are going to take advantage of everything for the struggle before you, do not ignore this simple but important factor. You may have read recently this shrewd advice: "Appearances are deceitful, but so long as they are, there is nothing like having them deceive for us instead of against us. A dirty shirt may hide a pure heart, but the chances are against its covering a clean skin." Orderly neatness in figuring and writing is an effective, if modest, recommendation. Some of the time spent in studying what Professor Bates characterizes as "language which, while it is English, is yet hardly more intelligible to the students than would be Choctaw or the speech of Borrioboola Gha" might be profitably employed in learning to write the language one is going to use. And by "write" I do not mean here any sort of literary composition; but merely "the mechanical act of tracing or inscribing symbols or ideographs." The written alphabet has been declared to be the greatest and most useful of all human inventions. If it is so, and as it is quite unprotected by patents, does it not seem strange that so many of us utilize this remarkable invention in such an unworkmanlike manner?

Having, then, a serviceable, legible system of characters or symbols, in order to make a record these characters must be arranged into accepted forms for conveyance of ideas. A second axiomatic concept of Record Making is, therefore,

"SYSTEMATIC ARRANGEMENT."

An orderly allotment, a systematic arrangement of symbols, of characters, of words, of terms, of every detail of a record is essential to make that record complete. It cannot be disputed that accuracy is enhanced by symmetrical, methodical apportionment and classification of data; and that the recording of the complete, precise, exact truth in some disorderly, chaotic, and confused way may result in error as great as that arising from erroneous information. To struggle through a perplexing labryinth of uncorrelated meanderings of truth, a maze of indiscriminately muddled facts, on a disentangling expedition is as trying to the temper as to discover that extensive calculations and careful deductions must all be discarded because of incorrect statements of preliminary data. For instance, I recall a man, a graduate of a reputable engineering school, who was instructed to keep a force account (the daily working time of a dozen laborers) in order to check the time-book supposed to be kept by an illiterate foreman. Now the foreman, in spite of his honest attempts, got his time-book so badly mixed that it was impossible to tell what was due the men at the end of a week's time

and the engineer, with a sheepskin passport from a considerate Faculty, was called on for his records; but, sorrowful to relate, they were in such condition that he himself could not discover how much was due to each man, or indeed with accuracy, to any man. Pages of figures, but no information; words, but no records! And so, at such a simple examination he failed, and he found that it wasn't just something to be "made up next term," hardly worth mention, for he had sacrificed the confidence placed in his ability to do anything well; and soon another took his place.

You will be forgiven for not knowing how to run the job your boss has, but lapses in the little things trusted to you will not be overlooked so easily. In the examinations to which you are coming, most of the questions will be very simple ones; but you will have to pass them every day.

Of all the deplorable, unsystematic record-making habits, none is worse than that of writing desultory notes on loose sheets. Records should be kept in books, or else bound into books or some workable substitute therefor. In some of the largest engineering offices in this country it is required that every figure be put down in a note book, that every arithmetical operation be shown, so they can all be found when the inevitable checking up comes. Too often it happens if notes are made on nondescript sheets, that they are misplaced or lost even before they are old, and one is sometimes forced to the undignified and annoying attitude of looking for them in the waste basket. Nothing is more irritatingly imbecile than to swoop deliriously on this scrap of paper or that scrap of paper in the sudden anxious hope that it may perchance bear certain information once recorded on a similar fragment. "There may have been times in human history when the action of the Turk who picks up and preserves every stray piece of inscribed paper, 'because it might contain the name of Allah' has been highly reasonable." But in these times a similar behavior is wholly uncalled for even in literary fields, while in engineering records it is an indication of a lamentable lack of that system and order which throughout engineering is a prime requisite.

You have read Alexander Pope's observation that "Order is Heaven's First Law," and you may recall that one St. John who had a heavenly vision, received as his first command a direction to make a record, a record of some permanancy—"What thou seest write in a book." As you start out in your engineering work remember St. John and Pope—"What thou seest write in a book,"—"Order is Heaven's First Law."

It is not necessary to say to engineers that their records must be solely of that which is true. Untrue records may be of service in other lines, but in engineering they would fail because of their falsity. An eminent jurist who had broad opportunity for observation of many men on the witness stand, gave his opinion that engineers as a class are the most accurately truthful men in the world. You are not dealing with man-made laws, you can't evade the law of gravitation; force and inertia are not matters of opinion; and experience will permeate you with a higher regard for truth than ever precept could.

Records of value should be of some permanency, and books instead of loose sheets are an advance toward that desideratum. Don't go around leaving "foot prints on the sands" for your engineering records. Your employer won't see much that is "sublime" about records so easily washed away. There is a story told of a rodman who was sent out to establish a bench mark in a railroad yard, who returned advising that he had located it on the draw head of a box car. He further explained to the thunderous silence which greeted him, that he had carefully recorded the number and initial of the car, and could find it at any time.

It is not improbable that your first records will be made in ordinary "field books" and properly will follow the usually prescribed standard form. But even such standard forms are sometimes so arranged and filled in that no one, not even the maker, after a time, can determine the meaning of the notes.

The field notes of a survey, of a pile driving outfit, of a force account, of anything, ought to contain all the information at hand in some sensible arrangement, so that some one else can discover what was done. This constant reiteration of one idea may seem to you a foolish repetition, but when you have had to sit and tear your hair in an effort to determine whether angles were turned to right or to left, or whether such a line is center line of track or center line of structure, or some equally provoking simple thing, you will acknowledge the correctness of this oft-repeated requirement. Surprising it is that the special and limited notes are nearly always included, while the simple essentials are omitted.

Somewhere in the book the proper general explanation should be given. For instance, a pile recorder may proceed systematically to call the piles in the bents Nos. 1, 2, 3, 4, and 5, and that much may be clear in the notes; while you may search in vain to discover whether he counted from north, south, east, or west. I have looked over old note books whose sole distinguishing title was "Line B"; no date, no name, nothing to indicate place or purpose.

The records made by all the different men connected with one enterprise should fit together to form a connected whole, and definite explanations are needed that there may be uniformity of arrangement of similar data. An example of lucid, explicit instructions of this character is to be found in Molitor and Beard's "Manual for Resident Engineers," a book which the novice will find to be an excellent basis of practical work, giving, as it does, clear ideas of actual duties and how to perform them, and in which the experienced engineer will discover many valuable hints and suggestions. Excepting that portion of the book treating of Specifications, you will find that one-sixth of the numbered paragraphs, covering over one-third of the whole book, are devoted to the duties of resident engineers with respect to records. You will notice that the details of these records, the form and size, the titling and numbering, the methods of report, are all carefully specified.

Field notes should be comprehensive and complete. In making them put down everything you think will be needed and then all the things you are sure you will remember. Of course, the engineer is busy (like the Habitant farmer—"No sooner one job's finish dan he got two t'ousan more"), and the time for note making is limited, so that while notes must be comprehensive they should be concise and brief. It is far better to err by making notes too plentiful than to have omissions. Attempt to come to the point as clearly as possible, but be sure everything is included. Two words need not be used where one would serve, but that one should not be omitted.

Don't be so brilliantly brief as was an engineer who was directed to check the material for a half-through girder span on a couple of cars, and who, instead of giving a memorandum like this—1G1, 1G2, 2FB1, 3FB2, etc., reported with much satisfaction "there are six big pieces and a lot of little pieces"! And he had told us he fully understood checking steel for shipment!

Make your notes thorough, make them brief if you can, but make them thorough anyway. The difficulty in accomplishing this was once forcibly impressed upon me when on a trip inspecting old bridges with a prominent engineer. We both made notes and he always finished his sooner than I. Nevertheless, when the accounting came and the notes were made into a report, mine were decidedly lacking and his contained information I had instinctively left to memory—to fallible memory. Sometimes I had even failed to state the number of spans, or the stream name, or the location number, or something else equally simple. Field notes should be comprehensive, but comprehensive with discrimination.

Perhaps following the work of making notes in prescribed forms will come the writing of letters and reports. While letter writing is not

mentioned in many treatises on engineering, it still becomes an important part of professional work. When you come to direct others in their work, you will do so largely by letter; and it will then be essential that you be able to write a letter which will really convey your ideas to its recipient. Some day you will be writing specifications for constructions to be read by men of very different abilities, of varying views, of complex relations, and it will be essential that your thought be conveyed accurately to each one.

Of course, the mention of writing simple sentences that clearly express one meaning without ambiguity, is smiled upon as being too elementary a detail for college men. Surely "grammar," "composition," "rhetoric," "literature" are household words; but if you were to make a practice of examining letters written by college graduates, you would conclude that "grammar" was a theory long ago discarded, that "composition" was not for personal application, and that "rhetoric" and "literature" were studied for "credits," not for use.

We agreed just now that poor penmanship is not necessarily an evidence of lack of culture; but this fact is sure—although a man may not disclose his character by his penmanship, he surely will betray his training by his use and arrangement of words and sentences. You expect to impress your employer and later your clients as an educated, scholarly man; can you, or do you even try, to write scholarly letters in simple sentences properly paragraphed? We commend or condemn authors by what they have written, and so will business men judge us by what we write and how we write it.

Specifications and reports may not concern you soon, but at the very outset of your professional career you will surely have occasion to write letters. A sloppy, slovenly, confusing, ambiguous letter produces the same effect as a display of dirty hands, unkept attire, and general personal untidiness. Your professors have told you this in substance, and have corrected your English; and you have considered their opinions to be due merely to their academic idiosyncrasies; but let me assure you that they have overlooked your lapses far more readily than will your business critics.

A word might be said regarding letters of application for positions. Perhaps you may sometime need to write one. You will then be judged by your letter, and it therefore deserves serious effort. Make it brief. Make it neat. If practicable, make it cover only one page. Spell the man's name correctly. Secure his exact title and address and use them. Give tersely enough information to enable him to judge the product you are advertising; at least so he will not have to write for preliminary data. Don't tell him you have had charge of every piece

of work you happened to be engaged upon, for he may know the man who really was in charge, and, in consequence, might have to start in by disbelieving you. And don't, as did one University man in a letter of application I have seen, don't spell "engineer" with a "j."

The recording of ideas by drawing is, to me at least, far more interesting that to put them down in writing. To originate a detail or combination of details and to inscribe on the drawing board your plan and your details so as to carry out your scheme is a most engrossing occupation. Many students, not understanding that drawing is a means for expressing ideas and that its character will depend on the ideas, decry the work of drafting. Truly a man working only with mechanical precision in stolid vacancy of mind, making letters on a map, or tracing some other man's conceptions, is limited in scope, and his work is drudgery; but no work can be of more absorbing interest than that of a designing draftsman who is constantly making inventions and recording them on paper. Pictured in his mind is a complete structure, and piece by piece he mentally puts it together, and plans and dictates how others shall actually put it together. Here, too, the same axiomatic, simple principles for records are applicable. The plan is made to convey a meaning.

Once I made a plan for a canal drainage gate that was to be better than anything on the whole of a large rice irrigation plant. Facilities for drafting were somewhat lacking, and the drawing was crowded on one small sheet; but to my mind that gate, and especially its manifold advantages, showed forth with unmistakable clearness. You can sympathetically imagine my indignation and the consequent commotion when I found my beautiful gate was being made as wide as it was to have been high, and the flaring wing wall had become a slide-way for the water to run over. The foreman produced the plan and I explained. When he grasped the idea he recognized its efficiency. But he said "that plan doesn't show *me* anything like that." And I then began to appreciate the principle that a plan should be so drawn as to appeal to the user, not to the maker.

Vast numbers of engineering records are made only by drawings, and the engineers must be able both to make them and to understand them. Skill in making drawings is like skill in writing and figuring. Don't possess yourself with the idea that if you are unable to make a clear drawing, neatly lettered, it will be accepted as evidence that you are meant for greater things. You are more likely to succeed to other positions through skillful drawing. And as drawing is the natural way and the only way for recording much engineering thought, you ought

to be able to draw well if you expect your thoughts to be clearly understood and to prevail.

Even in those cases where a drawing is for the use of the maker alone, it should be complete and definite. To stare confused at your own drawing and not find enough familiar lines to know what it is all about will quickly produce a genuine foolish feeling. Some draftsmen will make a large scale layout for a riveted joint in such a way that even the next day it is of no use to them, and they will have to make it over again, with additional expenditure of energy, or else get rivets on chance dots, and center lines for bearing lines, and wrong angles, and incorrect scales, and other numberless errors.

If you really intend to present your idea so that somebody else may carry it out, don't credit him with omniscience, or skill in mental telepathy, or a mind that moves in your individual track. Either give every detail of everything you propose, or else expect surprises as the doer applies his own ideas and perhaps achieves the required end in a manner entirely at variance with your own veiled, stealthy, and secret intentions. If you show a rivet floating around promiscuously in an area of possibilities, don't be astonished when it is put in some other than the exact spot you had in mind. Don't leave a space blank, and think that anybody ought to know that was "three inches."

The plan maker is responsible for the mutual correlation of the various parts, and he must give careful attention thereto. Usually in an extensive work, contractors or mechanics have plans only of their particular share, and they build in accordance therewith, trusting entirely to the detailer that their portion will fit with the work of the other builders. Especially when a change is made in one drawing or in one detail, it should be traced throughout all of the parts that may be affected and on every sheet of the entire set of drawings. For instance, I have set anchor bolts according to substructure drawings only to find later that the steel work would not fit, and then learned that changes had been made in the steel plans and had not been properly carried through to the substucture drawings.

If a drawing be for construction use, it is well to remember that however easy it may be in the drawing room to spread three or four sheets out on a desk and compare from one to another in order to find one lonesome dimension, it is entirely a different thing when you are shoe deep in mud with the rain dripping on your print, or when your fingers are so cold that they can hardly push a pencil, or perhaps when the tropic sun is beating on the back of your neck and one hand is busy fighting off mosquitoes, when your dearest wish is for a drink of cool water without any mud in it, and when the contractor is being

delayed and is roaring about for immediate instructions, and for points, and for explanations. Give a thought for the man who is to try to follow out the plan, and arrange the data as nearly as may be for his advantage and convenience.

Aside from ordinary mistakes and avoidable errors, the principal deficiencies of drawings as records are largely due to a lack of conception on the part of the maker as to how the user will perform the work. This suggests the natural conclusion that only that man who has done the class of work involved can really properly prepare a plan. While this is not generally practicable, it is always possible for the designer or detailer to have clearly in mind just how he would take each step if he were to follow the plan and build thereto. Your structures cannot spring into existence complete and perfect from your Jove-like brow, but must be put together piece by piece. It is not uncommon to find in steel-work plans instances of members which must first be taken apart before they can be put in place, and rivets which no earthly riveting tool could possibly drive. Many times I have had to make over plans for substructure, supposedly complete, plentifully supplied with dimensions, but yet lacking nearly every dimension required for staking out the work on the ground. The maker of such plans should prepare his drawings with the thought that he might be called on to stake out the work, and to direct the carpenters in their form-building and the other mechanics in their various efforts.

A carefully made plan is certain to save time and labor by having the thinking done at the outset once for all. But the information must be so arranged that a meaning, one meaning, the intended meaning, is made clear to the user. Above all, for plans to convey information there must be information to start with.

Final records of completed works are of special value both for private information and for public reference; and they aid greatly in the advancement of the engineering profession. Some times anxiety to stop expense immediately on the cessation of the construction causes records to be left in an unfinished condition—a most expensive economy. Notes should be final, completed, indexed, and arranged as soon as possible after making. For instance, it may become of importance to know quickly just how deep the piles of a trestle were driven, or what load a certain floor was designed to carry, or what pressure per square foot was allowed on a certain material, or even who inspected certain work. All too frequently such data are entirely neglected. Recently in an important matter none of the city officials were able to find in their records any definite information concerning the depths of piers in a city bridge built only a few years previously. The remembrance of some

workmen was their most reliable record. Such conditions are prevalent —they are not exceptions; and engineers are to be blamed for such folly. When a work is completed it is best to make a new drawing showing the structure as actually built; or if this be considered extravagant, a special set of blue prints should be marked in red ink "as built" with each altered dimension corrected. Such drawings or prints should be dated and properly filed with a report or general statement concerning the work.

Aside from the personal or local value of a record of completed work, there is a value to the profession at large. We advance on former accomplishments: the best way to forecast the future is to examine the past. To this end it is essential that records be made of the design and construction of completed works and that their plans be available for study and comparison. This is being done by the technical press and in the publications of engineering societies. No two pieces of engineering construction are exactly alike; the engineer must constantly, with versatility and judgment, adapt old ideas to new conditions; and the clearness with which new conditions are recognized and the aptness with which the old ideas are applied measure the ability of the engineer. The fundamental laws of machines are known to every man, or can be learned with ordinary diligence; but the application of the principles resulting in the complicated mechanisms of today demands laborious effort, vigilant patience, and unceasing enthusiasm. Never again should it be said that there are "lost arts," never more should mankind travel again and again the same slow paths of the development of the arts. Future generations should surpass us by knowing both what we have done and how it was accomplished.

There is not a single piece of important engineering work done anywhere, concerning which it would not be advantageous to some one to know exactly how it was performed. The simplest thing to those who know is yet as abstruse as matters most profound to those who know it not. An engineer once told me that he had an extensive but unsuccessful search made in one of the best engineering libraries in this country, in order to find a description of how to put up an ordinary frame bent trestle—a simple enough thing, surely, for those who know.

The younger members of the profession rightly expect that those of mature experience should devote some time and effort to a record of their accomplishments and failures for the general good, in order that each success, no matter by whom accomplished, may ultimately lead to a greater. And while the young engineer may not assume to instruct those superior in wisdom and experience, he may still have a share in such records, if only by contributing statements of facts and tabulations

of data. And if no one other than himself ever examines his final records, they yet have a genuine value.

In order to give you a better appreciation of the variety of records encountered in engineering work, I shall take as an example a contract covering the construction of a number of bridges for a railroad in Mexico, which was of the cost-plus-percentage variety, and endeavor to trace through the various records required.

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You thus see that the Engineers were concerned not only with plans, specifications, surveys, field notes, inspection reports, and estimates, but with cost-keeping, accounting, money exchange, invoicing, bills of lading, bookkeeping, and all the records required for the conduct of business. You will have noticed too, the magnitude of the labor involved in reducing these records and in classifying results for proper comparison. Such reduction is common in records of many kinds and is sometimes carried to extreme refinement. I have heard of a mine superintendent who was such an enthusiast for comparing averages that he was reported to compute each day the average daily car number of the cars loaded at the mine.

A somewhat just criticism of the training of our engineering schools is made in that, being usually prematurely vocational, it fails to educate. Another criticism more pointed, and in some respects not wholly unjust, is that, although such engineering training is principally vocational, it fails to train.

Now, frankly, you all expect to sell something. That something is your services. Some day it may be your opinion, or your judgment; but your opinion is not now of much value, and you will find it hard to realize cash on your judgment. Your services you perform with hand and brain, and what you do with your brain is expressed with your hands. So with your training you should try to train your hands.

Suppose now, everyone of you were to write a letter to my firm requesting employment. You would each receive an answer that your letter had been placed on file. Do not cherish the belief that "on file" means "lost." Some day a man or two is needed and the file is examined. So far as we know, you are all alike, all graduates this year of an engineering school of repute, about the same age, of about equal experience. Now who do you suppose will get the job? The letters are all examined and one by one discarded, this one because it is careless, that one because it is in such bad writing that evidently the writer will not be able to make a neat drawing, another one for having gross mistakes in spelling, still another because it shows that the writer has absolutely no knowledge of how a business letter should be phrased; so

finally the position is offered to the writer of the cleanest, neatest, most careful letter. And every employer of engineers in the country follows more or less the same plan, perhaps not consciously, but inevitably, because the only thing he has to gauge you by is that letter.

Now suppose you are all working side by side in a drafting room, and some special work comes up. Who do you suppose will be chosen to do it and so begin to raise himself from the general level? You know: it will be the man who is doing the neatest, clearest, most accurate work with his drawing instruments. Suppose you wanted to choose one out of ten men, otherwise equal, to advance to the designing department, which one would you select? Assuredly you would take the man who could make the neatest, most orderly estimates, whose writing was legible, and whose figures were plain. Suppose you were all working in equal positions in a field corps turning in notes every day, and one man was to be selected for a better position. Do you believe it would be the man whose notes are always smudged and dirty and irregular and inaccurate? Frankly now, other things being equal, who will get the raise? Certainly, there are other things, other characteristics, that will be the determining factors later, but for your immediate future nothing is more important than neatness. Neatness is evidence of carefulness, and carefulness of accuracy. By the time you have to design a truss or an engine, you will have forgotten all you know about it today, and will have to take up your books and study and really learn it, but what you are unable to do in writing and figuring will be noticed now.

You may be able to advance rapidly in spite of your illegible writing and careless drawing and dirty notebooks, and you may be confident in assurance that you will; but, do not forget that you will be pulling a heavy drag all the time. I could show you men who never have taken the positions they deserve solely because of that drawback.

When you get something for nothing, usually you have paid full value. Good records do not merely occur. Time and effort are the price—strenuous, sustained, painstaking, monotonous effort. But the price will not be paid in vain.

An engineering student, therefore, should not only aim to learn how to conduct a survey, how to design a structure, or how to inspect a material, but he must also learn how to make records, *intelligible records,* of each effort.

Recapitulating,

Records are for Information.

They should be

Legible, Concise, and Comprehensive.

to which end there should be
Skillfully Made Symbols,
Orderly, Systematic Arrangement, and
Definite Ideas of Information Desired.
They should be
Permanent, Accurate, and Intelligible.
Memory is Fallible, Paper is Cheap.
Books Were Invented to Keep Together Loose Sheets.
A Record Correct Once is Correct Forever.

Take up your record-making till in time you yourselves will add to those "epics of engineers, perhaps unsung in words, but being written in huge characters on the face of this planet."

You have ideals, cherish them; you have ambitions, follow them; you have determined to make your mark in the world; make it. But when you do make that mark, in the name of all good records, make it so clear and so plain that other folks shall know, beyond the peradventure of a doubt, exactly what it stands for!

SOME EDUCATIONAL PROBLEMS IN A LARGE UNIVERSITY.

By

Professor Vladimir Karapetoff.

This paper was written as an address to alumni and not for students. The main reason why it is offered for perusal to entering freshmen is that they may understand some of the problems which the Faculty has to solve and to enable them to sympathize with it in the difficulties with which it continually has to contend. Another reason for presenting this address to freshmen is that it treats of the emotional part of college life—an aspect which is not generally recognized by either instructors or students—at least not with sufficient seriousness.

The ethical features of this paper and of the other two papers by Prof. Karapetoff given in this book are earnestly recommended for the student's consideration and guidance. It would be well were there in the engineering profession more of its representatives who, like Prof. Karapetoff, do not hesitate to treat in print openly and fearlessly the moral and ethical questions that are so important to both students of engineering and practicing engineers.

Vladimir Karapetoff was born in St. Petersburg, Russia, in 1876. His father was a mechanical engineer, and his mother studied medicine. He was educated in the common schools of Tiflis and Baku, Transcaucasia, and in the Imperial Institute of Ways and Communication at St. Petersburg, where he took the degree of C. E. in 1897. In 1899 and 1900 he studied electrical engineering at the Technische Hochschule at Darmstadt, Germany; and in 1902 he defended a thesis for the degree of M. M. E. in St. Petersburg. From 1897 to 1902 (with intervals) he was instructor in electrical engineering in three different colleges in St. Petersburg and lecturer in the evening classes of the Imperial Gun Works. From 1904 to 1908 he was Assistant Professor of Experimental Electrical Engineering in Cornell University, and since 1908 he has occupied the chair of Electrical Engineering in that institution.

He devotes considerable time to music (piano), and appears in public recitals. He has given several series of lectures on musical subjects, among others Wagner, Liszt, and Musical Expression.

He takes an active part in socialist propaganda, and has lectured in defense of socialism on several occasions.

He has written a great number of valuable books and papers on engineering subjects in Russian, German, and English.

He is a member of the American Institute of Electrical Engineers, the Society for the Promotion of Engineering Education, and the American Association for the Advancement of Science.

His practical engineering experience covers hydraulic, railway, mechanical, and electrical work in Russia and Germany and considerable electrical work in the United States.

At present he is spending his sabbatical year in the employ of J. G. White and Company, Engineers and Contractors of New York City.

Such a wide and varied experience for a man only thirty-five years old is phenomenal; and it certainly ought to stand him in good stead in his chosen specialty of Electrical Engineering Instruction.

Editors.

SOME EDUCATIONAL PROBLEMS IN A LARGE UNIVERSITY.*

By

Professor Vladimir Karapetoff.

The ultimate end of education is to develop the latent possibilities of the individual, so as to bring them into better adjustment with his environment, and to fit him for realizing the highest ideals of the times. The education of the soul comprises that of the intellect, emotions, and the will. This gives a natural classification of the problem confronting our educators.

I. *Intellectual Side of University Life.*—The great problem is "what to teach," and "how to teach." The common-sense "practical" man would probably say: Why, teach law to the lawyer, teach medicine to the doctor, engineering to the engineer; and teach them in a plain, practical way, so that the students can understand and apply the knowledge.

This "horse-sense" advise is based on the assumption that a young man or woman between eighteen and twenty-two is a piece of soft material, that can be shaped into any desired form. Alas, Mr. Business Man, fortunately it is not so. They are free, thinking, feeling, and willing (or rather unwilling) beings, and to make them assimilate our teachings is at least fully as hard as for you to sell goods to your customers. Human education is not a mechanical or chemical process, or even to be compared with the training of monkeys. It is an organic process of self-development; the school merely provides conditions favorable for such self-development. With the best teachers and first-class equipment, we fail with certain individuals, and these individuals are not necessarily stupid or lazy. They simply choose not to develop according to prescription, and we ought to be glad that there are such individuals. They keep before our eyes our most precious gift—freedom of choice. I would not part with this gift for the sake of burdening the country with a few more "stuffed" college graduates.

Evidently, it is impossible to give a general answer on "what to teach," and "how to teach." I wish only to call your attention to the fact that these two problems are confronting us all the time. Success in teaching depends primarily on two subtle psychological factors: live interest and well directed conscious effort on the part of the student. You, gentlemen, are stimulated in your present activities by many potent

*An address before Cornell Alumni of Pittsburg on August 29th, 1908.

incentives, such as immediate useful results, notoriety, increased profits, desire for promotion, fear of discharge, and so on. All these incentives are virtually lacking with our students, and unless we wish to use the methods in vogue with ancient Egyptian taskmasters, we have to rely on the spontaneous interest and effort on the part of our students.

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Another educational problem of great importance is the relation between professional training and general culture. Most of our students desire in the first place a professional training that shall give them a livelihood. Again, the recent progress in most branches of practical activity is of such a tremendous scope, that fully four college years are required for professional training alone. But it is felt by the best educators that it would be wrong to deprive large masses of professional students of the benefit and pleasure of general culture, wrong towards themselves and towards the country.

Now, in the first place, what is general culture? My answer is: Man's life is divided between furnishing services to and receiving services from society. General culture comprises such studies as better enable a man to receive and to enjoy services from society, while professional training enables him to give better service to society. From this point of view, French literature, botany, or even the steam engine. can be studied either as a profession, or for general culture. You will see from this definition that the principal aim of education—development of all of the man's latent powers—is not complete without a fair amount of general culture.

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II. *Emotional Side of University Life.* Young teachers are often baffled by a sudden outbreak of laughter in a class, at an apparently insignificant word, a gesture, not at all comical to an outsider. I am no longer offended at these outbreaks since I came to understand their cause. A man needs emotions as a part of his mental life, and a young man or woman of twenty needs them badly. The college life offers so little opportunities for emotion that the student instinctively looks for any small occasion to laugh, to yell, to whistle, to run, even to see a dog-fight. He is like a prisoner who is glad to share his solitude with a spider. We are apt to condemn students for going to trashy shows, for horrid mandolin playing, for taking an exaggerated interest in ball games, for spending time in saloons and doubtful down-town resorts. But, gentlemen, once natural channels for emotions are throttled, unnatural channels are sure to open up. I know, some of you would say, that students do not care for Shakesperean plays, classical concerts, and readings from Browning; true, because these things are not purely emotional, they require considerable concentration and training for their

enjoyment. Not only is the average student not prepared to understand higher art, but he objects to using his intellect in it, since what he wants is a pure play of simple emotions. Watch him sit at the theater, and rock, and whistle a catchy refrain with the chorus; only an ignoramus would say that his mind is dormant or lazy. His emotions are playing intensely; he enjoys in his imagination the part of life that reality has cruelly deprived him of. Five-cent shows with their highly-emotional performances have filled a long-felt want for brain workers, and for people whose life has much drudgery in it.

Now, instead of deploring and condemning, let us see what can be done to give students the necessary emotions. Said old Darwin sadly at the end of his life: "If I had to live my life again, I would have made a rule to read some poetry and listen to some music at least every week; for, perhaps, the parts of my brain now atrophied would thus have been kept alive through use. The loss of these tastes is a loss of happiness, and may possibly be injurious to the intellect, and more probably to the moral character, by enfeebling the emotional part of our nature." Through lack of emotions man is dwarfed both esthetically and ethically, and if he is thus dwarfed during his student years, the probabilities are that he will continue to drag his burdens through life without sunshine and love, like a mule in the mine.

What then is to be done? My answer is: provide more opportunities for the enjoyment of art and for social intercourse. The very nature of the case precludes compulsion, at least in the beginning. We must proceed slowly, because a lack of appreciation of art is a general fault in this country; the remedy must begin at home and in the common schools. I am aware that good work is being done for the development of artistic taste; this gives me courage to see the time when each student will be required to pursue in the University the study of at least one form of art: literature, poetry, music, painting, sculpture, in their various manifestations. Mind you, he will pursue them for the emotional pleasure that is in them, and not for drudgery or any utilitarian purpose. With a proper preparation in the high school it will be difficult to find a student who would not manifest even the slightest interest in these arts.*

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III. *Volitional Side of University Life.*—Just a picture: a man is drowning in the river, and a horrified crowd watches him from the shore; one of the spectators hastily takes his coat off and jumps into the water to save the struggling one. Is this the man who is the best swimmer, or a man whose emotion of pity is more deeply aroused than that of

*As I understand, the only required subjects in schools in Ancient Greece were music and the study of the Homeric poems.

anyone else in the crowd? Not necessarily; he is a man whose *will* is trained to obey the dictates of the intellect and the heart. In my estimation, an educated man with all his vast knowledge and refined emotions is a failure unless his will is trained to do what he knows and feels he ought to do.

Our watch-word must be: *"Cornell men are trained to do things;"* this was the ideal of the founders of the University—Ezra Cornell and Andrew D. White—men of great deeds and high practical achievements. Some of you may think that the business of the University is to teach, and not worry about students' emotions and wills. We feel, however, that our purpose is not fully accomplished unless we graduate men and women who not only *know* and *feel* things, but who actually *do things* when the time comes to act.

Now, the will, like any other faculty, grows by exercise, and the difficult side of the problem is: How to organize University life so that students should have enough opportunity to exercise their wills, to choose, and actually to bear the consequences of their decisions. The student undoubtedly has to exercise his will in going to the lectures at appointed hours, in preparing his recitations and reports, in voting for class officers, and in taking part in various students' activities. But this is far from enough: He or she is guided too much from without, and the consequences of a student's decision are not at all in proportion to the differences in the motives. During the last panic a considerable number of engineering apprentices and of trade apprentices were laid off by a large concern for an indefinite time. The foreman of the apprentices told me that trade apprentices took this event in an entirely different way from college graduates. The trade apprentices, being used to rely upon their own resources, immediately began to plan their program of action, while college men seemed to be hopelessly lost, as soon as they could no longer follow a program arranged for them by others. I should be loath to think that college education weakens the will while developing the intellect, yet I do not see much in our University life that is conducive to the development of the will.

The manager of a large company in the Middle West told me recently that in filling positions with college graduates he always gives preference to those who have been prominent in students' activities. "It does not matter," said he, "whether the man distinguished himself in athletics, in politics, or in literary activity. It simply means that he is a man of strong will and initiative, a man who can be relied upon to achieve results, without an external pressure."

I think, this is a correct view regarding students' activities, and it is from this point of view that we must encourage them. The greatest difficulty is to induce a large mass of students to take a moderate part in

these activities, instead of a few becoming experts and almost professionals, while the rest are satisfied with watching them and cheering the favorites. * * * * * * * * *

We often hear from our Alumni and from various employers of our graduates: "Why do you not teach your students this or that; this is of great importance in practical life." The tendency is, at least in the colleges of applied science, to teach too many things in a general way, and none thoroughly. This is detrimental for the development of the will, since the student has no opportunity for concentration and for original study and research. The problem is to organize the courses so that the student gets enough general information, and at the same time some practice in special research, in which he has to exercise his judgment and will. But to achieve this, the course must be lengthened by at least one year.

I have indicated a few general educational problems that we have to deal with in our University. In addition to these, there are problems of wide national and international character, that affect instruction and reflect upon the students' life. As such I would mention great differences in the wealth of students; low standards and ideals, as a result of greed and struggle for existence outside the University; indifference to philosophical discussion and to religious duties, because of the uncertainty pervading our economic and political life; use of liquors, loose morals, and a low estimate of women; indifference to the great political and economic issues of the times, and a tendency to follow demagogues and bosses. All these things students bring from their homes, imbibe from papers and magazines, and inculcate from one another. We are endeavoring to counteract these harmful tendencies by all the means at our disposal; and yet these being the curse of the times, our work is successful only in proportion as we have the support of agencies outside the University. The American people as a whole must make a determined effort to free themselves of the remains of barbaric times and establish a new commonwealth upon higher standards of thinking and living.

HINTS TO STUDENTS ON THE EDUCATION OF AN ENGINEER.

By

Dr. Ira. O. Baker.

Dr. Baker is one of America's most distinguished engineering instructors and authors, and his advice to students should carry great weight. No one who reads the following paper can fail to be deeply impressed with the soundness of its doctrine, the profundity of its thoughts, and the elegance of its diction. It certainly is one of the most important of all the papers that the Editors have collected. Students are earnestly urged to read, ponder upon, believe, and follow the advice herein given by one who is universally acknowledged to be a great leader in technical education.

Dr. Baker graduated in 1874 at the University of Illinois in the Civil Engineering Department, went into general practice for six years, then returned to his *alma mater* to teach, and has remained there ever since, devoting his energies to the development of that institution and to the advancement of the engineering profession through his writings. These comprise books and papers on masonry construction, roads and pavements, surveying instruments, leveling, and similar subjects. Everything that has come from his pen has been accepted by the profession as standard and authoritative.

Editors.

HINTS TO STUDENTS ON THE EDUCATION OF AN ENGINEER.

By

Dr. Ira. O. Baker.

Before Civil Engineers' Club of University of Illinois

March 28, 1887.

A recent discussion of civil engineering education in a prominent engineering journal by eminent professors and practicing engineers, suggested this subject. That discussion had reference mainly to the facilities which should be possessed by an institution professing to educate civil engineers; this article will have reference to how you as students of civil engineering may make the most of the opportunities offered by this institution.

First let me remind you of the three elements of a true education,—development, training, and information. By the first I mean the capacity for abstract conception and reasoning; by the second, the formation of correct habits of thought and methods of reasoning, and the training of the hand to execute and the eye to see; and by the third, the acquisition of the thoughts and experiences of other men, and of the truths of nature. The development of the mental faculties is by far the most important, since it alone confers that "power which masters all it touches, which can adapt old forms to new uses, or create new and better means of reaching old ends;" and without this power the engineer can not hope to practice his profession with any chance of success. The formation of correct habits of thinking and working, habits of observing, of classifying, of investigating, of understanding, of getting clear and distinct ideas, of proving instead of guessing, of weighing evidence, and of thoroughly honest work, is a method of using that power economically. The accumulation of facts is the least important. The power to acquire information, and the knowledge of how to use it when obtained, are of far greater value than any number of the most useful facts. There is no comparison between the value of a ton of nails and the power to make a single one.

The student, particularly of the technical courses, not infrequently reverses the above order, and assumes that the acquisition of information, especially that directly useful in his proposed profession, is the most valuable element of an education. Probably this error is owing to a misapprehension of the aim of a technical school. It is assumed that

the object is to fit the student to earn his livelihood more easily, and that, therefore, the institution should give him the maximum amount of information and practice directly applicable in his professional work. If this idea were to prevail, there would be no difference between a technical college and a trade school, and the product would be skillful machines instead of educated men. The prime object is to make the student a wiser and stronger and more complete man, and at the same time to train and develop his faculties in the direction most useful to the engineer. This end is sought to be accomplished by coupling the mental development of the student with the acquisition of training and information directly useful in the exercise of his profession. The best results would be obtained if the student should cultivate and expand his power by pursuing a general course before entering upon the technical studies. The lawyer, the doctor, and the preacher, all take a general course and then the special. Why should not the engineer? Can the engineering student, in four years, accomplish as much as the student of law, or of medicine, or of theology does in seven? Is it wise for the engineering student to neglect that preparatory education which in the professions of law, medicine, and theology has long been recognized as essential for a professional education? An eminent, practicing engineer has said that "no greater mistake was ever made than that which asserts that the engineer does not need to be liberally educated."

Next let me emphasize the fact that it is best to follow one of the regular courses. If for no better reason, take a prescribed course because of the experience of the early graduates of this institution. In the beginning no degrees were given, and our graduates found themselves seriously handicapped by the lack of the usual evidence of a collegiate education. A few students, although they propose to take the prescribed course, wish to change the order of topics. The courses as printed are probably the best, and following them certainly obviates any conflicts in times of recitation. In the mind of the student there is always some particular reason for departing from the course; but experience shows that in most cases, the student himself subsequently sees that he chose unwisely.

Many students who follow a regular course take some extra studies, but not infrequently make a mistake in selecting them. These extra studies afford an opportunity for the student to broaden his field of knowledge, and in choosing them the three elements of an education should be steadily borne in mind. Generally they are selected because of their supposed immediate bearing upon the work of the chosen profession. For example, a student in civil engineering, wishing to take an extra study, selects architectural drawing, because it will increase his skill in drawing and therefore the better fit him to do any of that kind

of work that may fall to his lot after leaving college. Whereas, having obtained the principles of drawing and the practice necessary to explain their application and to fix them in his mind, it would be wiser to employ his time at something else and wait for the practice which comes afterward to obtain skill in drawing. If he selects architectural drawing with a desire to learn something of the principles of architecture, and holds the mere technic of drawing as subordinate to the principles of architectural construction or ornamentation, he chooses wisely. But, on the other hand, if he takes the subject because he thinks it will be useful in designing a depot or round-house, he will probably not derive much benefit from the study, for if the professor seeks to illustrate an important principle by reference to a triumphal arch or an ancient cathedral, the student will probably turn a deaf ear and allow his mind to wander to the time when he hopes to get a large salary for copying the drawings made in the recitation room. A student having an opportunity to take an extra study should select one that will develop some neglected intellectual faculty, or train his hand and eye in some new direction, or store his mind with a new class of ideas. In pursuing it, let him try to discover the spirit of the new subject, note the character of the data considered, and compare the method of arriving at the results with those employed in the topics with which he is more familiar. In connection with the question of extra studies it is well to remember that three acres plowed deep generally yield more than four plowed shallow.

However, the spirit with which the student pursues the studies of his chosen course determines the amount and quality of the education he gets. There are three things which sometimes unduly affect the interest, and consequently the progress, of a student in his studies. 1. His estimate of the relative value of the different topics in the education of an engineer; 2, the supposed practical bearing of the topic upon the actual work of his profession; and 3, the immediate influence of any class of information in securing a position after graduation.

1. He thinks that the best engineering education is to be obtained by giving as much of his time as possible to the technical subjects. The great multiplication of knowledge has made this an age of specialists, and if one would attain the highest success he must devote his attention to a narrow field; but he can not know one subject thoroughly until he knows something of others. It is not expected that the engineer shall also be a learned linguist, nor a practical analytical chemist, nor an expert geologist, nor a profound physicist; but he must have some knowledge of these topics before he can practice his own profession creditably.

2. He often makes a mistake in his estimate of the bearing of any topic upon the actual work of his profession. For example, he thinks the adjustment of the surveying instruments is more important than descriptive geometry, while the fact is that he who is well grounded in the principles of descriptive geometry will be able to adjust any instrument at sight. Again, students are always more interested in railroad engineering than in analytical mechanics; and they consider it far more important to learn a method of keeping transit notes than to understand the method of finding the angle at which a force acts at the best advantage in dragging one body upon another. The first gives information only, while the second gives the three elements, mental development, intellectual training, and information. Judged, even from the student's point of view, the latter is of more practical importance; and, farther, he who has the ability fully to comprehend it can devise a form of keeping his notes which will probably be better for him than any he can get from any one else. It is far better to be able to own the machine which turns out nails by the tens of thousands than to be able to hammer out a few by hand. Civil engineering education in America may be said to have commenced with the building of the Erie Canal. What think you would have been the effect, if the engineering student of that day had been content to limit his studies to those branches which he thought would be directly applicable in canal building? Would he have been able to solve the problems necessitated by a new mode of transportation? No one can foretell the development of the future, or the possible practical bearing of any topic. A few years ago students in physics desired to omit electricity, "because it was of no practical importance;" while only a year or two afterwards their successors wanted to give all their time to that branch, "because of its great practical importance." A broad scientific training is the best preparation for any branch of engineering.

3. The attitude of a student toward his studies is often affected by the idea that, if he would get a position after leaving school, he must make his education "practical." The demand for technical graduates seems to be increasing, but it is certain that they are not sought after solely because they have crammed their heads and their note books with rules and formulas. The most simple operations require the exercise of that good judgment which comes only to him who has paid the price by a study of those things which cultivate and expand the intellect. The man who learns simply the practice of his day will soon be "behind the times;" he is a machine to be laid aside when a more profitable one is found. But he who has caught the spirit of growth is the one who makes precedents and determines the practice of his times. The latter only is able to solve old problems under new

conditions; he only has the good judgment necessary to know when to be exact and when not to be exact; he only understands that there is very much that books and formulas can not include. The wonderful material development of our country in the last quarter of a century, together with the scarcity of technical schools, made it possible for poorly educated and unripe engineers to find employment; but the conditions are rapidly changing. The evidence is abundant and conclusive. The new problems demand higher engineering ability and wider knowledge. The wise young engineer will prepare himself accordingly.

In conclusion, there is one point on which I hope there will be no mistake. I do not wish to be understood as claiming that a general education alone is a sufficient preparation for the practice of civil engineering. The best technical training must be founded on a thorough scientific education. Although a man with a general education could "pick up" the necessary special information without attending a technical school, it would be to his advantage, both in the final result and in economy of time, to pursue a technical course. The special engineering school not only develops that quality of mind most suitable to the engineer, but also gives him information and practice which it has been abundantly proved are of great utility in the practice of his profession. On the other hand, it is not claimed that students immediately upon graduation from the technical course are engineers of mature judgment, although as a rule their training and attainments enable them to make a rapid growth.

But, finally, let no student pursue an education alone for its material ends. He should strive to be not only a trained specialist but also an educated man, and some day, if not now, he will see that the latter is as desirable as the former.

THE PRACTICAL ENGINEER.

By

Onward Bates, C. E.

This address was delivered in December, 1909, to the Civil Engineers' Club of the University of Illinois by a civil engineer who has attained great success in the practice of his profession and who has been honored by the highest distinction which that profession can bestow upon any of its votaries, viz., the presidency of the American Society of Civil Engineers.

It has been found necessary to omit certain parts of it which are not specially fitted for the purpose of this book, notably both the beginning and the ending. What has been retained consists mainly of good, sensible advice. The Editors can heartily endorse what Mr. Bates says concerning the importance of correct spelling, for in their practice they make a point of rejecting all applications for positions, when such applications are misspelled. Of course, every man is liable to make a slip in spelling occasionally, often from carelessness rather than lack of knowledge; but a grossly misspelled letter is a sure indication that its writer has not been as thoroughly educated as a graduate engineer should be.

What Mr. Bates says about the lack of ability of many young engineers to write letters and to talk is unfortunately too true; and this defect is far more important than most people deem it. The persistence with which American engineering students as a class ignore the study of English is simply disheartening. It seems almost impossible to force them to believe that a command of their native language is at all essential to their professional success.

This paper is written with great force and vigor, and its teachings are true; consequently it behooves both students and young engineers to give heed to its instructions and profit therefrom.

Mr. Bates was born February 24, 1850, in St. Charles County, Missouri. In March, 1865, he entered the Fulton Iron Works, St. Louis, Missouri, as an apprentice, and learned the trade of pattern maker. In August, 1868, he attracted the attention of the late Col. C. Shaler Smith, who, by the way, was one of the finest men and one of the greatest engineers that America has ever produced. Col. Smith, who was then building a bridge over the Missouri River at St. Charles, asked the proprie-

tor of the Fulton Iron Works to cancel the apprenticeship and turn Mr. Bates over to him. This was done, and Mr. Bates worked on that structure for a year; then, by Col. Smith's advice, took a position with one of the Contractors on the substructure of the Eads bridge at St. Louis, on which work he remained two years. In 1871, by the advice of Col. Smith, he went to the Rensselaer Polytechnic Institute, where he took a special course for two years, then returned to work on the Eads bridge for the Baltimore Bridge Company. From 1874 till 1877 he was employed on the Cincinnati Southern Railway in various positions, then entered the service of the Chicago, Milwaukee, and St. Paul Railway, where he remained for a year.

In March, 1878, he went to Australia as representative of the Edge Moor Iron Company, remaining there three years, during which time he directed many important constructions.

On his return to the United States he was again employed by Col. Smith, and later became President of the Pittsburg Bridge Company. Next he served for a year as mining engineer in Mexico, and afterwards worked again for the Edge Moor Iron Company. In 1888 he entered the service of the Chicago, Milwaukee, & St. Paul Railway Company as Engineer and Superintendent of Bridges and Buildings, remaining for thirteen years and doing a great deal of exceedingly good and important work.

From 1901 until 1907 Mr. Bates was President of the Bates and Rogers Construction Company, a most successful contracting firm. Since 1907 he has retired to a certain extent from active practice, but is still greatly interested in matters professional.

In 1895 the University of Wisconsin conferred upon him the honorary degree of Civil Engineer, and in 1909 he became President of the American Society of Civil Engineers.

Editors.

THE PRACTICAL ENGINEER.

By

Onward Bates, C. E.

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If I give you a lecture on words, it is not wholly inappropriate under the title of the Practical Engineer. We are not dummies; words are as necessary to us as to others, and in our profession more necessary than in some others. I will not ask if each of you knows his letters, accepting that much without question; but I do question if each of you knows how to spell. If you do, it is more than some practical engineers do. Correct spelling is an accomplishment; a man is frequently under-rated just because he has made some mistakes in spelling. It is also a matter of importance, for sometimes the idea one wishes to convey is changed by a mistake in spelling. It is important to know the meaning of words, in order that you may say or write what you mean. How can one expect to write specifications, or draw up contracts, if he does not know what words to use, and what construction can be put upon them when they have been used? In addition to spelling correctly, and using words whose meaning you understand, it is still more essential that you should know how to string them together. Our profession is exact in its nature, and should be precise in its expressions of fact or opinion, written or spoken. There is no occupation in which it is more important to say precisely what is meant to be said. The engineer's opinions should be expressed with the same regard for accuracy as is used in his mathematical computations.

Can you write a letter? Some engineers cannot. They may write what purports to be a letter, and can perhaps make their correspondent understand the ideas they wish to convey. I do not ask if you can write legibly; that seems to be a lost art, and is not, in these days of typewriters, to be expected. Yet the writing machine is not always at hand, and bad hand-writing is far more risky and impolite than mumbling of words where you have the opportunity to apologize and repeat them. I mean, can you write a letter, stating in clear, distinct, concise, and correct language the facts and opinions which you wish to make known to your correspondent? If you cannot, then your education as an engineer is incomplete.

Do you know how to talk? To talk well is a great art. You can please, you can plead, you can instruct, you can command, or you can

rebuke, in each case with the right use of words, and the right degree of emphasis, if you can correctly use the English language. Engineers take pride in being workers; they like it to be said of them that they are the people who do things. In fact they seem to feel rather above talking, leaving that for the common people to do. Nevertheless they do talk, and not always to the best advantage. In the most momentous affairs they get others to talk for them, and when, as sometimes happens, they fall under the necessity of making arguments, explanations, or demands, they suffer from inability to do justice to their cause. We may say that anybody can talk, and that some people make a business of talking; and yet mature observation leads one to believe that scarcely any other talent is more serviceable and more profitable. Talk, like every other commodity, is valuable not for its quantity but for its quality. There are times when a few words of wisdom are worth more than volumes of nonsense, although the latter has its value at other times.

The command of the English language is a necessity as well as an accomplishment. It is the language of the profession, and it is fast becoming the language of the civilized world. The knowledge of this language is an essential requirement of the educated engineer; it is a necessary part of his equipment, and we may call it one of the tools of the profession. We attach great importance to the other tools, and in my opinion have neglected this important one. How often do we observe an engineer, who has an excellent technical education, and who can apply it in his work, and yet lacks the facility of language which qualifies him to engage in discussions of a general nature with men of other occupations.

The preceding discussion of words and their use may seem to you more appropriate for an address in a primary school than in a Civil Engineers' Club. It was purposely introduced, to call your attention to one of the short-comings of the practical engineer. Assuming for the sake of argument that it is a short-coming, then who is responsible for this condition? It may be the fault of the University, in not teaching the subject. Or, if the professors make the excuse that a knowledge of the language should be acquired before entering the University, it may be their fault that they have not enforced this requirement. It may be your own fault, in failing to avail yourselves of your opportunities in the University and in the preparatory schools. Whosesoever fault it is, if you are deficient in this respect, I advise you to rectify the deficiency. You can do this on your volition. There are many practical engineers who are self educated, and who have acquired a good command of language. The means for this acquire-

ment are at hand and consist principally in conversation with those who speak correctly, in reading good books, in studying examples of well written letters, in a constant use of the dictionary, and in a consideration of all that one speaks or writes. Many a man who has no acquaintance with text books on grammar, has succeeded in acquiring a correct use of language by availing himself of these means; and if you keep good company, and read good books, this accomplishment is naturally and easily acquired.

This dissertation on the use of the English language is intended to call your attention in a pointed manner to a weakness of the practical engineer which has been the subject of frequent criticism, and as this is only one of the many faults which are found in him, to prepare your minds for the consideration of the general criticism, that the engineer, as compared with men in other occupations, is narrow and one-sided. I speak now of all engineers, practical and otherwise.

Let us consider this general criticism.

If it is without foundation it cannot stand and we can refute it. If on the other hand, there is reason for it, we ought to study ourselves and remove any causes which warrant it. Speaking from my own experience I think the criticism is a just one. I have personally felt myself handicapped by fixed ideas, narrow views, and a stubborn purpose of proving myself to be in the right. Again for the sake of argument, let us assume that engineers in general possess these faults, and let us look for the causes of them, and seek the remedy for them. Is narrowness of mind an inherent quality which leads one to select engineering as his vocation? I reject this query with scorn, and only mention it to dispose of it at once and altogether. Having progressed so far, we know that we must look for the causes outside of the individual. It must then be due to his education, and I think the trouble is located in the University. The professors may demolish me for this statement, but I have a right to make it; for I am a member of the National Society for the Promotion of Engineering Education. I am also a member of a National Committee to consider the Status of Engineering Education. I objected to serving on this committee, on the ground that I was not a college man, and was jokingly informed that it was a case where practical engineers were needed to balance the professors.

Having made the general statement that the University course, as applied to students of engineering, has the effect of graduating men who are narrow and one-sided, it is incumbent on me to give my reasons for this statement. In the first instance, professors of engineering are usually specialists, and they generally teach their specialties. If one is a master, as he should be, of the special subject

which he teaches, it is natural and to be expected that the importance of that subject is magnified in his mind when compared with other branches of the science of engineering. In his efforts to impart the knowledge of his specialty to the student, the latter forms his opinion of the specialty and is much influenced by the personality of the teacher. If the subject is one for which the student has an aptitude or liking, it obtains a preference in his mind over other subjects. He becomes more proficient in it and he attaches more importance to it. This criticism applies in a general way to each of the professors constituting the Faculty of an engineering college. This Faculty is composed of a number of engineers, each one selected for his knowledge of the science of engineering, and for his ability to teach some special branch of that science. It is an old saying, that it takes nine tailors to make a man, and I suppose it takes at least that many professors to make an engineer.

Many years ago I was asked to give an address as a practical engineer to the students of the civil engineering department of Cornell University. I arrived at Cornell the day before my address was to be delivered, and was shown through the buildings and introduced to the professors. At first I was very much in awe of them, and it seemed to me impertinent that I should presume to address students who were under the instruction of men, each of whom was a high authority in some line of professional knowledge. I was appalled at my own ignorance and wished myself at home. However, as I became acquainted with these learned men, I discovered that each one held to his own specialty, and was most deferential to his brethren who taught other specialties. Then my mind began to clear up regarding them, and I reflected that while I could sit at the feet of any one of them and be instructed in his specialty, there were lines of practical engineering in which I was perhaps more competent to obtain results than he was. With this comforting thought I braced up and talked to the young men with confidence, as I am now talking to you. Do not, for one moment, consider my remarks as in any sense derogatory to engineering professors at this or any other University. They command my admiration, for among them I see men of undoubted talent and knowledge which would bring them far better pecuniary recompense for their labors, and far greater appreciation from the public, if they were engaged as practical engineers instead of professors. Theirs is an example of true devotion to the profession, and doubtless they feel that it is a higher grade of work to make engineers than to practice the profession.

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I have recently heard the statement made that the study of mathematics, and of other subjects which require precise and concentrated

application, has a tendency to cause the mind to move within narrow or restricted limits in the direction of such concentrated application. How much of truth there is in this statement I am not enough of a psychologist to determine, but I can readily understand the possibility of some such effect; and if it be granted that it is a fact, instead of a possibility, we must look to the Universities to provide the remedy.

The function of a University is not so much to store a certain amount of knowledge in the minds of its students, preparatory to their graduation, as it is to qualify them for taking their places in the world as men among men. As a corollary of this statement we may say that the knowledge of mathematics, and of the use of instruments, does not make an engineer. This knowledge is absolutely essential, for one cannot be an engineer without possessing it; and to avoid being misunderstood, I wish to say, with the utmost emphasis, that it is impossible for an engineer to have too thorough a knowledge of any thing which is required in the practice of his profession. At the same time, if you only know mathematics and the use of your instruments, and you enter the actual practice of engineering using the mathematics and the instruments to accomplish certain results, you are not practicing the profession but reducing the profession to the status of a trade. It is a common error among engineers, and particularly among the younger men of the profession, to assume that they are only to do in practice what they have been taught to do in their study of the profession, and to do it in the identical manner in which they have been instructed to do it. The engineering profession, rightly considered, is an extremely broad one; and the young engineer, who desires to attain eminence, must cultivate breadth of character, of judgment, and of methods, to qualify himself for high rank. If he has failed in the University in securing this broad education, it is essential that he get it after he leaves the University.

How to make the University course more comprehensive is a problem for the professors to solve. My present object is to prove to them that the problem exists. If I can do this, and obtain from them an admission of the necessity for broadening the course of instruction, they will find a way to do it. This necessity is impressed upon me by observation of their graduates. These graduates look for employment in the lines of work in which they are most interested. They remember their favorite study under the influence of the professor whom they personally admired, and they desire, if possible, to follow in practice the lines upon which their minds were trained in the University. They begin as specialists and continue as such. This is commendable within certain limits, for the range of engineering work is so extended that it is necessary to specialize in practice. The objec-

tion to it is that the engineer's mind seems to be closed against other specialties. I have known a man of talent, a graduate civil engineer, who was employed on stress diagrams for truss bridges until he seemed to be impressed with the idea that the making of these diagrams was the sum and substance of engineering. The same effect may be noticed in men employed in other lines of work. The young engineer does not as a rule grasp the opportunities which are ahead of him. He may have a remote idea that some day he will be a chief engineer, that great works will be under his charge, that important questions will be submitted to him for decision, that he will be called upon to plan great structures and to solve large problems; but just how these honors will come to him he does not know. His mind does not go much farther than to think that they will come to him when he gets older. He should keep these things before his mind, and work toward them, remembering that they come as rewards for those who have shown themselves competent to receive them. He should continually work and study with the determination to earn these prizes, and he should remember that each day's work is a step in that direction. If he qualifies himself for advancement, he will find that advanced positions are inviting him to appropriate them. He must be broad to comprehend and secure these advancements. If he is content merely to practice those things which have been taught him, and to secure the results which he had been taught that computations and processes will bring, and to rest satisfied there, feeling that in this he has done his duty, he will be what may be called a Journeyman Engineer, and he will not secure this advancement, neither will he be entitled to it. There are certain qualities of mind which young engineers do not possess, because they have not learned them. One of these is the quality of discrimination; the ability to determine between right and wrong, good and bad; what should be rejected, what is acceptable; and what is to be desired and striven for. In other words, an engineer is not fitted for high position unless he is judicious. When a man is working for his monthly stipend, with certain fixed duties, or under the direct orders of a superior, it is hard for him to realize the value of a judicial mind and to train himself for judicious conduct. In a subordinate position he cannot appreciate the judicial requirements for an engineer who is sufficiently advanced to be in charge of work, and especially to be responsible for great undertakings. As he rises in the scale of rank he is more and more of a judge with each degree of advancement; a judge of materials, of processes, of expedients, of the qualities of his fellow men and of their abilities to do certain things; a judge of general effects, and a judge of right relations. The judicial faculty is frequent-

ly the most important of any which is possessed by the engineer at the top. This quality, and the ability to obtain results through judicious decisions, may to some extent be inherent in a man, but to a far greater extent it is the result of study and practice. This is one of the qualities which I should like as far as possible to be instilled into the engineer while he is at the University. It is your duty, young men, to consider all of the steps between your present position and one at the head of the profession, and to train yourselves continually with the purpose of making the latter place your final destination. Look up and climb; the way is as open to you as to others. There is no royal road to success for an engineer. The way is open to each one of you, and your success will depend more upon yourselves than upon all other influences combined. While I tell you to look high and strive for a place at the top, let me caution you that it is not to be obtained by going too fast. You may make a mistake in failing to consider that great rewards will be yours if you earn them, and you are equally liable to make a mistake in assuming that you will get them without earning them. Success means an improvement at each step. You cannot skip any of the steps; you must be thorough in everything you do. You must be reliable in small as well as in large trusts. There is no quality so much appreciated by those who have need of your services, and who are in a position to promote your advancement, which is as much valued as the quality of reliability. If you leave any gaps behind in your progress upward, they may at some inopportune time be a snare to you; for when you look backward for the supplies which you are depending to be furnished over the road of your past experience, they may be wrecked in the gap which you have left, and you may find that you have reached the limit of your advancement. In past times men have attained distinction as engineers who had no college education, and very little school education of any kind. Some of our oldest and most respected practitioners belong to that class. These same men, however, could not start over and succeed under existing conditions. They have the experience which enables them to employ men of better education than they received, and are respected on account of what they have done; but their class is rapidly dying off. At the present day it is useless for any one, who has a proper ambition to be among the first in his vocation, to attempt the engineering profession without a University education. Let me encourage you to strive for the final purpose of your education, and let me congratulate you on the great opportunity for preparation offered you in this University.

There is one more specification in the charge against the engineers of a narrowness of vision, and it is this, that those of us who are

zealous, over-estimate the value of the profession. I would not, for one moment, say that we should not work as hard as we do, nor strive as much as we do for great results and for honorable position; but let us not forget there are other things beside our profession. I love to think of the engineer's profession as a manly one; and yet there are claims on our manhood which take precedence of the profession. First of all we must remember what is due to our families, and then come our duties as citizens; then our duties to our fellow men, and among these is our special duty to our brethren in the profession. If we are determined to broaden ourselves we must associate with other people, and become integral parts of the community. We should engage in all sorts of good works, and we should not neglect an interest in politics. Take for an example of an engineer's delinquency, the performance of his political duties. In so far as I know, most engineers do not even vote. Possibly they do not know the names of the candidates; or if they do know their names, they may not be aware of their principles and policies. If all work and no play makes Jack a dull boy, then by analogy the giving up of ourselves wholly to the practice of engineering makes us narrow men, and limits our engineering opportunities. There is no good reason why an engineer should not cultivate and enjoy the society of his fellow men. As a side issue, to counteract the narrowing tendency of his exact and exacting occupation, he should stroll in the fields of literature and art and general science. He ought to be familiar with the libraries, the museums, and the art galleries to which he has access. He should read the best of current literature, and should acquaint himself with history. He should study nature and learn its great lessons at first hand. He should improve his mind by taking care of his body; and healthful exercise, with friendly rivalry in active sports, is good preparation for professional work—all this of course within reasonable limits. If he plays golf, it is not required that he shall be a golf fanatic; and if it is foot-ball, he can afford to stop short of maiming his opponents. To be broad he must avoid extremes in all things. The setting of one's profession on a pinnacle, to be worshipped as the only real object in life, is unwholesome, and it defeats its own ends. Engineers should be seen at other places than at a desk, or leaning over a drawing board, or squinting through an instrument. They ought to be found where their fellow citizens congregate for any purpose affecting the common good, and they should take their part in such meetings.

They should be interested in charity and philanthrophy and should have their share with others in movements for promoting the health and happiness of mankind.

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SOME RELATIONS OF THE ENGINEER TO SOCIETY.

By

Colonel H. G. Prout.

The author of this address is one of America's most prominent engineers. In his younger days he served with distinction in the Egyptian army, where he attained the rank of Colonel. For many years he edited the Railroad Gazette, returning, however, from his editorial work to active professional practice.

A careful perusal of this scholarly paper must give to the reader some conception of the magnitude and importance of the engineering profession; and it should also arouse the enthusiasm of engineering students and encourage them to do their utmost to become worthy members of that profession. The Editors recommend their readers to purchase and read the book mentioned by Col. Prout entitled "The New Epoch as Developed by the Manufacturer of Power" by the late George Shattuck Morison, C. E., for it is one of the great masterpieces of engineering literature. Being a copyrighted book, it was not practicable to reproduce it in this series of addresses.

Henry Goslee Prout was born in Fairfax County, Va. He served the last two years of the Civil War in the Army of the Potomac. in the Wilderness Campaign, the Siege of Petersburg, and the pursuit and capture of Lee's Army. He graduated from the University of Michigan in 1871 with the degree of C. E. In 1902 Yale University conferred on him the honorary degree of A. M.; and in 1911 he received from the University of Michigan the degree of LL. D.

From 1873 to 1878 he served in the army of the Khedive of Egypt, first as Major of Engineers and later as Colonel of the General Staff, commanding an expedition in the Soudan and succeeding Gordon as Governor General of the Provinces of the Equator. He had afterwards a few years of engineering and business experience, and then for sixteen years he was editor of the Railroad Gazette; and the high character of that paper's editorials and general make-up was due primarily to his scholarly taste, engineering ability, high ideals, and painstaking care.

Since 1903 he has been Vice President and General Manager of the Union Switch and Signal Company, dividing his time between his New York and Pittsburg offices.

He is a member of the American Society of Civil Engineers, and for a long time he took an active interest in the affairs of that organization, serving a term as Director.

Col. Prout, while still in active and hard work, can justly look back upon a well and usefully spent life; and his eminent services to the engineering profession ought to be to him a continual source of profound gratification.

Editors.

SOME RELATIONS OF THE ENGINEER TO SOCIETY*

By

Colonel H. G. Prout.

In the summer of 1903 an eminent engineer died in New York, Mr. George Shattuck Morison. He was a man of broad education and of a powerful mind and illustrious achievement. Like most engineers he wrote but little, but he left behind him a manuscript which was afterwards printed in a book of one hundred and thirty pages, under the title of "The New Epoch as Developed by the Manufacture of Power." You can read it easily in two hours, but it sums up much of the reading and meditation of a vigorous and intellectual life.

Mr. Morison reminds us that students have recognized certain great ethnical epochs in the progress of mankind. The use of fire first lifted man out of the condition of the animals around him; then came the use of the bow and arrow which further established his superiority. The next great step was the use of pottery, and man passed from savagery to barbarism. The domestication of animals and the manufacture of iron marked two more eras in the development of the race. Finally came the use of the written alphabet, the greatest and most useful of all human inventions, by which knowledge could be preserved and distributed. Progress thus became continuous and great masses of mankind were enabled to advance simultaneously along the same lines. This was the step from barbarism to civilization, and there the ethnical periods are considered to have closed. What has followed is assumed to be but the natural advance of civilization. But Mr. Morison thinks that there is no apparent reason why other epochs should not come, just as distinct and just as important as either of the six which are behind us. It but needed the discovery or the development of a new capacity to make a new epoch, and such a new capacity came with the manufacture of power. By the development of the manufacture of power man's capacity is suddenly increased beyond any limit which the human mind can forsee or imagine. The strength of man or the strength of animals no longer sets a boundary to the capacity to do

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*An address delivered at New Haven in the Sheffield Lecture Course, February, 1905; at Ithaca at the First Annual Reunion of Civil Engineering Alumni of Cornell University, June, 1905; at Wilkinsburg before The Electric Club, November, 1905.

work. Forms of matter are changed, and the forces of nature are set to do our bidding, and we can see no stopping place in this process. The power of man to do useful work has been multiplied in the last century beyond all computation or imagining. In the last one hundred years man's productive capacity has probably advanced more than in all the preceding years that he had inhabited this planet, and the revolution wrought by the development of the capacity to manufacture power has just begun; the door has just opened.

I think it was Mr. John R. Freeman who estimated that in one voyage across the Atlantic a steamship develops as much power as was developed by hundreds of thousands of men working through decades of time to build the great pyramid; but the biggest ocean ship is small compared with the great power factories which we can see all around us, and this power is delivered in our houses and in our shops and on our railroad tracks, to the immense saving of time and energy. It would interest you to try to compute the human effort saved by the mere fact that some hundreds of thousands of maids and housewives draw water from spigots, where it is delivered from steam pumps, instead of going to wells. How can we measure the effect on human society of the fact that two men in a locomotive cab haul two thousand tons of goods or five hundred passengers across half a continent at forty miles an hour, or of the fact that every steam hammer in a forge shop does the work of a dozen men, and does it better?

While the capacity of man to do accustomed things has been multiplied, he has been empowered to do things that he could not have done before. The steel forgings that are made now could not have been made at all by man-power or animal-power. Manufactured power was necessary to the production of the great structures of to-day—the ships, the guns, the bridges, the great engines in the power houses, the tall buildings in the cities. Perhaps there are those now before me who doubt if human happiness has been increased by the mere capacity to produce big things. You will remember Ruskin's ideal society, with the happy peasant in a velvet jacket singing in the fields, the heavens unpolluted by the smoke of mills and the air unvexed by the noise of railroads. Not long ago a professor in a neighboring great university maintained with some heat the superiority of the Greek civilization, when the mass of the people lived in squalor and built Parthenons, as compared with our civilization when the mass of the people are more sure of food and clothes and fuel, and build ugly steel frame Masonic Temples. We cannot stop here to discuss the relative value of civilizations, but I make bold to believe that the average of human happiness was never so high as now.

The examples which I have cited only suggest the amount of human effort that has been set free by the manufacture of power. My imagination is unequal to the task of giving you more than a hint of the change in man's condition which has just begun, and even to-day the manufacture of power, an art a little more than a century old, is in process of evolution. The prime mover of yesterday will not be the prime mover of to-morrow. Our methods of using the stored heat energy of the sun to-day will be history twenty-five years from now.

It is less than one hundred and fifty years since Watt made the reciprocating steam engine a thing of actual use, and fairly began the era of manufactured power. Already the reciprocating steam engine is doomed, except for certain special uses. The development of the transmission of power by electricity has made it possible to use the high efficiency of the steam turbine, and the use of turbo-generators is even now large and spreading fast. But the turbine is only a step. Its successor is already foreshadowed in the gas engine. Side by side with these changes in the type of prime mover advances the art of transmitting and using power by electricity; and so swiftly does the art advance that now the day seems close at hand when we may see short but important lines of steam railroad of heavy traffic converted to electric working. The power houses will be equipped with steam turbines or with gas engines. Alternating current will be sent out over long transmission lines and stepped down and used in the car motors without converting. Two great things will be accomplished. Working cost will be reduced and the public will have more frequent, cheaper, and perhaps swifter service.

These are a few of the great engineering changes now visible over the horizon. If we had time we might speak of others in the fields of transportation, of sanitation, and of manufacture, which will possibly have even more effect on the wealth and happiness of man than those which I have mentioned. For instance, who can foresee the effect of countless small improvements in manufacture which are flowing from the swift development of mechanical, electrical, and chemical knowledge and skill? And perhaps even greater results will flow from improved sanitation saving present waste of human energy. And these changes are close at hand.

We may reasonably suppose that twenty-five years from now, when many of the young men now sitting before me are in the full tide of their useful work, these United States will have a population of one hundred and twenty million. That will be more than the present population of the United Kingdom and France and half of Germany combined. It will be a free and homogeneous population, more

efficiently educated than any people the world has even seen. It will be a population of singular daring and enterprise, this for two great reasons. For ten generations the Americans have lived under conditions to develop courage and enterprise; and the immigrants coming to our shores must be, generally speaking, class for class, more courageous and enterprising than those whom they have left behind or they would not have come. This population, so vast in numbers, so efficiently educated, so courageous and enterprising, and so free to work, each man in his own way, will be seated in a temperate climate, amongst unrivalled resources of soil and mine, in a country intersected by great natural waterways and covered with a net work of railroads and with a vast coast line on the two great oceans. Put into the hands of such a people, so situated, the means for the manufacture of power and their influence on the world, physical, intellectual, and moral, may be greater than the influence of the men who built the Roman Empire, greater than the influence up to this time of the race which built the empire of the English-speaking people. What a glorious thing it is to be a young American at the dawn of the new epoch!

These matters of which I have just been speaking are important. They are occupying much of the best intelligence of the world. They are pursued with most admirable enthusiasm and devotion. But regarded in a broader way they are only incidents in the general forward movement of the new epoch. Not only have we entered on another ethnical period, but upon the most important period in the progress of mankind. It is quite conceivable that a thousand years from now men may look back to the 19th and 20th centuries as the most significant period in the history of the race.

Perhaps you begin to wonder where I am coming out, perhaps you are already asking what all this has to do with the announced subject of my lecture—"Some Relations of the Engineer to Society."

My proposition is that the engineer, more than all other men, has created this new epoch and that the engineer, more than all other men, will guide humanity forward until we come to some other period of a different kind. On the engineer and on those who are making engineers rests a responsibility such as men have never before been called upon to face; for it is a peculiarity of this new epoch that we are conscious of it, that we know what we are doing, which was not true in either of the six preceding epochs, and we have upon us the responsibility of conscious knowledge.

If we are right in the notion that the manufacture of power has brought mankind into a new ethnical period; if we are right in the notion that the engineer is the man who beyond all other men has

created the new conditions and who must beyond all other men carry them forward in their development, then we are face to face with certain facts of tremendous importance to two classes of our fellow citizens: First, to those who are responsible for the training of youth for their work in the world; and, second, to those young men who have chosen engineering as their profession.

The same events and conditions which have created the new epoch have affected the plans of education, and, so far as I am qualified to judge, those who are training the young men who are to guide the human race in the next few decades are working forward in the right direction. It is obvious that our aim must always be to acquire a more complete and perfect knowledge of the forces of nature, and to this end we must have mathematics. Years ago Prof. Bartlett, in the introduction to one of his remarkable books, said that the man who is endowed with the priceless boon of a copious mathematics possesses the key to the external universe. It is my observation of a good many young men starting as engineers that their mathematical training is defective. Instead of holding a key they have a feeble grasp on something as vague as fog; they have not been trained to use their mathematics as a tool for investigation, or for analysis, or for conclusive reasoning. Perhaps we may attribute this partly to the survival down to this day of Plato's notion that geometry is degraded by being applied to any purposes of vulgar utility.

Close to this is physics. A command of those facts and laws which we roughly group under the head of physics is more important than a command of mathematics. A mere mathematician cannot be an engineer, but a man can be an engineer with limited mathematics if he has a working conception of the laws of physics. My favorite test of the intellectual power of a boy is to ask how he stands in physics. A high stand there is a pretty certain indication of imagination, of power to analyze, and of capacity to reason.

Command of the forces of nature requires besides mathematics and physics a specific knowledge of those branches of learning which we call the natural sciences. The relative importance of any one of these to any one man must depend upon the kind of work which he intends to do, but some knowledge of almost all of the natural sciences is important to the engineer, and a large and definite knowledge of some of them is necessary.

But mathematics and physics and the natural sciences are not the end. If an engineer is to go far, he must have some of those studies which give him broad and just ideas of the relations of man to man, and of man to society.

The duties of my life bring me into daily contact with large industrial and commercial interests employing many men, and I may say in all sincerity, and with due regard to the meaning of my words, that it is far easier to hire engineers than it is to hire men.

It is my constant observation of four engineering works, employing about 20,000 men, that engineers reach the limit of their usefulness from defects of character, rather than from want of technical attainments. Our greatest difficulty is to find courage, candor, imagination, large vision, and high ambition. I do not know which of these qualities is most often lacking, or which is most essential. The lack of courage and candor comes most often to my notice, but the lack of imagination and of broad outlook produces the most serious disasters. All of these things an engineer must have if he is to go far, and all of these any citizen must have if he is to go far in the work of life. Our scheme of education will be radically defective if it does not provide for the development of courage and candor, of imagination and broad vision and high ambition. Our scheme of education of the engineer and the citizen must also teach our youth something of the large mistakes of men and nations in the past and something of their successes. Lacking that teaching we see the farmer in Texas and the third rate lawyer in Congress and the professional friend of mankind in Nebraska re-inventing ancient errors and diverting valuable energy from the useful purpose of hoeing corn. It is not for me, not even an amateur in education, to say how these things should be reached, but I venture a suggestion.

Scientific study may be in itself a great expander of the imagination. You will remember that Prof. Shaler wrote five dramas in blank verse to prove this. I am not competent to judge of his demonstration, but at least I venture the assertion that the study of chemistry or of biology, of machine design or of analytical geometry, of geology and astronomy, is as quickening to the imagination as the study of Greek or Latin grammar, of moral philosophy or of rhetoric, or as a formal and routine study of English literature. The result is mostly dependent on the teacher and not on the thing taught. The quickening influence is the human influence.

This brings me to another suggestion. Gordon used to say that it would be better if the young British officers were made to read Plutarch's Lives. "There we see men of no true belief, men who are pure pagans making their lives a sacrifice as a matter of course. In our day it is highest merit not to run away." This is a fertile suggestion under which lies a truth of the greatest importance in the scheme of education. At this moment we may see Plutarch's men fighting for

their country on the other side of the world and showing noble devotion and a lofty idealism, because for centuries and centuries great ideals have been held always before them. Admiral Togo's little address to the spirits of the dead the other day in Tokio was a noble inspiration to the youth of his nation. It had the very spirit which made Plutarch's men immortal. The essential thing is to bring youth into habitual and constant contact with great men and great ideas and great deeds. Make them read Huxley's Life and Letters and Lord Roberts' Forty-one Years in India and Grant's Memoirs. Or, perhaps better than any of these, let them read deeply in the story of Lincoln's life. There they will find the simple foundation qualities, love of truth, courage, patience, and fortitude, tenacity and devotion, working in great fields of effort. If these examples do not stir a young man, you had better let him go quietly back to hoeing corn. He may make a useful man and a necessary man, but he cannot make a great man or even a big man. Huxley has said that the progress of mankind has been through the production of men of genius; but society cannot deliberately and consciously produce men of genius. They are the rare fruit of a thousand uncontrollable conditions, but we can deliberately and consciously develop leaders, and the affairs of men have never called for leaders so loudly as now.

I said a while ago that we are face to face with certain facts of tremendous importance to those who are training young men for engineering, and to those who have chosen engineering as their profession. I have suggested a few considerations, more particularly for those who are educating the young engineer, and now let us turn to the engineer himself.

It is my proposition that the engineer more than any other man has brought about the new epoch which we have now entered upon and that he more than any other man is to lead mankind forward in the next century or two. But who is this engineer to whom we assign such a place in human progress? What is engineering? These claims, so broad as to seem extravagant, must rest on a broad foundation.

You will have observed that of the six great forward steps taken by the human race as a race, five were enlargement of his physical powers and improvements in his material welfare, through conquests over the forces of nature, and the sixth of these great steps worked for his advancement by enabling him to preserve and distribute knowledge. Even that step probably had its greatest value in hastening the conquest of nature. So we must not be surprised to discover that progress is through knowledge of a material universe.

Some eighty years ago Tredgold made that famous definition of engineering which has never been improved upon. It is the art of directing the great sources of power in nature to the use and convenience of man. Broadly this definition must include the physicist, the chemist, the biologist, the geologist, and the metallurgist, for they discover those laws and properties of matter in the knowledge of which the engineer must work. Narrowly the engineer is one who, having knowledge of the laws and properties of matter, designs and constructs. The primitive engineer, the man who had that instinctive feeling for the forces of nature and for the properties of matter, and that quality of contrivance which must be born in a man if he is to be an engineer at all, taught his fellow savages to use fire, to use bows and arrows, and to make pottery. Then he taught his fellow barbarians to use the strength of the larger animals and to smelt and forge iron. Just so the modern engineer using the same heaven-sent qualities is carrying forward the conquest of nature until he has brought us into this last and greatest era, the era of the manufacture of power.

I shall not stop to name his doings, they are written across the face of the earth. You remember what Carlyle says of the English "Of all nations the English are the stupidest in speech, the wisest in action. Thy epic, unsung in words is written in huge characters on the face of this planet—Sea-moles, railways, fleets and cities, Indian Empires, America, legible throughout the solar system, England her mark." Such, too, is the epic of the engineer written in railways, canals and bridges, in fleets and harbors, in water works, roads and parks, and finally in the great ultimate struggles of mankind on the battle field to save and destroy nations. There, too, the engineer writes his tragic poetry. You never thought of him as a poet, did you, and yet in the last one hundred years the highest expressions of the creative imagination have been in the work of the engineer.

A few years ago Mr. Abram S. Hewitt said that Sir Henry Bessemer had done more than any other man of his time to destroy the power of the privileged classes in Great Britain, that he was the great apostle of democracy. Bessemer's service to mankind was to lower the cost and increase the quantity of steel and so make possible the enormous development of transportation in the last half of the last century, which has changed the face of society, and I do not believe Mr. Hewitt over-estimated the importance of Sir Henry Bessemer's achievement. The wheat that makes a loaf of bread is carried from Dakota to New York for one-third of a cent. One day's wages of a mechanic will carry from Chicago to Liverpool food to last him a year. Quick transportation has cut the peasant loose from the soil of his little

parish and opened the markets of the whole world for the labor of the artisan. All this means that improvement in transportation has been one of the powerful forces for preserving and spreading liberty. Thus Bessemer was the apostle of democracy. The engineer has made life freer and easier, he has helped to destroy arbitrary class distinctions, and he has prolonged human life.

I shall not dwell longer on what the engineer has done. I wish especially to take a little time to point out some of the things which he is about to do. Bear in mind that in what I shall say I use the term "engineer" in its broadest sense to indicate the man of modern scientific education and of practical contrivance. Trained in daily contact with exact and inexorable laws he is becoming more and more a leader in large affairs, he is fast taking his place at the head, and close to the head, of the great industrial concerns. Mind, I do not say that he will displace men of other professions. Men bred to the law, men trained in business, will always rise to the top. Superior men will make their way to command through many different avenues. What I do mean to say is that the education and experience of an engineer especially fit him for high administrative positions not now commonly thought of as engineering work. Carlyle tells us that "Frederick the Great's ambassadors are oftenest soldiers. Bred soldiers, he finds, if they happen to have natural intelligence, are the fittest for all kinds of work." In Frederick's time engineering as a profession did not exist. Soldiering came nearest to it, and there is great likeness in the work of the engineer and the soldier and in the qualities of mind and character developed in the two callings. Both must ascertain physical facts without mistake. Both must analyze and weigh evidence and must reason correctly. Both must deal with relations of time, space, force, and matter. Both must handle men in action. Both must have the restrained and disciplined imagination to project clearly conditions and results which they cannot see. Both must decide, often very quickly, knowing that on the decision hangs success or failure. But this is the training which makes men of action—leaders, commanders. No doubt you will agree with much that I have just said, but I question if you will quite appreciate the gravity of the sudden emergency work which comes in an engineer's life. Suppose you are putting down a deep foundation alongside of a twelve story building in New York City and the quicksand begins to run and the walls of the big building to crack. The peril is not so pressing as the peril of battle for you can stop work and think. But you must think straight and act right or you will cost someone a lot of money, even if you kill no one. Suppose you are putting in a foundation for a bridge pier in the bottom of the Mississippi and the river

bed begins to scour and a caisson as big as a house begins to tip and to move down stream. A great deal of money depends on what you do in the next few hours. Suppose you are putting a tunnel under the St. Clair river and the compressed air begins to blow out through a pocket in the river bed. Here is an affair of minutes, and of life as well as money. These very things have happened and are exactly the things that come as a matter of course in an engineer's life, and they are met by just the same qualities of courage and stored up skill and emergency judgment that you must have ready when the enemy gets on your flank. Beyond all this the engineer is, of necessity, a student of costs and economics. He must know what it costs to move a yard of earth and to put in a yard of concrete and why. He must know what it costs to produce a horse power. He has been defined as a man who can do well for a dollar what any man can do somehow for ten dollars. Beneath all this must lie sleepless fidelity to his trust.

These are some of the qualities of leadership, obvious, and recognized as produced in the contest with nature; but there are others, higher ones, not so obvious. I mean the qualities of moral leadership. Probably you never thought of the engineer as a moral leader, and yet I have often thought and said that in a knotty case of applied morals I would sooner trust an engineer than any other man. I once said this to that famous moralist, the late Speaker Reed. It was apparently a new thought to him. He reflected as much as a quarter of a minute, which was a long time for him. "Yes," he said, "I guess you are right, a minister has no sense of proportion in sin." That thought is a little too delicate and complicated for me to follow further, but the lawyer is fair game. You will remember the saying of Macaulay on this matter. "We will not at present inquire whether it be right that a man should, with a wig on his head, and a band around his neck, do for a guinea what, without these appendages, he would think it wicked and infamous to do for an empire; whether it be right that, not merely believing but knowing a statement to be true, he should do all that can be done by sophistry, by rhetoric, by solemn asservation, by indignant exclamation, by gesture, by play of features, by terrifying one honest witness, by perplexing another, to cause a jury to think that statement false. It is not necessary on the present occasion to decide these questions." Nor is it necessary for us here to decide a question which every law student has debated over and again. For my present purpose it is enough to say that the daily practice of a profession concerning which such questions can arise puts a man of weak mind or weak character in very considerable peril of becoming a skillful sophist and a weak moralist. Even in the daily walks of

business there is frequent temptation to obscure the truth. But the man who passes his life in contests with nature is not apt to be a sophist. The engineer can have no object in concealing the truth or in misusing it. His work is a material fact; it is not an impression upon the minds of other men. No trick of words, no art of speech, will make his bridge stand up, or his bearings run cool. No ingenuity of argument, no power of rhetoric will save one ounce of coal per horsepower-hour. We all know in some vague and abstract way that we must yoke our wagon to a star, but the engineer must do it. The law which guides him is not the product of the schools and the courts, it is not the product of changing standards of life and thought; it is the eternal law of nature. So far as he finds it and follows it he succeeds; so far as he misses it he fails, and there is no escape for him. Nature always stands watching him, neither kind nor cruel, but perfectly just—swift, inexorable, and inevitable—at once his guide and his judge. Who else of all mankind has a discipline so fine? Reward is so prompt, punishment is so swift and sure. Emerson has said—"The mind that is parallel with the laws of Nature will be strong with their strength."

I have pointed out some of the special and peculiar qualifications of the engineer for leadership. There is another which he enjoys in common with other professions. I mean that which we may call the professional spirit. It often seems to me that some of the great dangers to the social order which we see around us will be lessened, not cured but lessened, by the growth of the influence of the professional man in affairs. We are worried about the growth of corporate power. I don't believe that corporations are worse managed than they used to be, but they are bigger and stronger and we hear more about them, as we hear more about most things. However all that may be, we shall not change human nature by law, and corporate nature is human nature. I see much good to come from the growth of the professional spirit in corporate management. The professional spirit is in its essence the sense of trusteeship. When the professional man takes in trust the affairs of his client, that trust becomes more binding upon him than his own personal interests. I am often amazed when I think of the vital force of this professional spirit of trusteeship. I am often astonished when I think of the great number of very common-place men who work along year by year with sustained devotion to a true standard of professional duty. It confirms my faith in the notion that the mass of mankind like to do their duty if they can only know what it is, and that the mass of mankind desire the approbation of noble minds. It is my impression that the true professional spirit is at least as strong

amongst engineers as in any other profession, and I am often tempted to think that it is stronger. Here then we see still another reason to look forward to the leadership of the engineer.

Those of you who have been dozing or wandering while I have talked and who have caught only the high spots will have received the impression that I have been claiming the earth and the fullness thereof for a small group of our fellowmen who have chanced to band themselves in a certain profession. My real purpose has been to call attention to the commanding importance in the advancement of mankind of a certain sort of training, and I had hoped that the presentation of this thought, while not at all novel or original, might have a certain interest to you, gathered in the shadow of this noble university, and especially to the young men.

I have said that the engineer brought about this seventh epoch in the progress of the human race, the era of manufactured power, but I am not sure but we should go back three hundred years to Lord Bacon. It was Bacon's purpose to teach man to gain command over nature, and he taught that this could be only by diligently learning the truth and then following it. And this is the real significance of the engineer as an ethnical force; he must know the truth and live by it. Bacon was not the first man to observe natural facts correctly and to reason from them simply and boldly. The savage engineer who taught his fellows to make fire must have done that. But Bacon roused great numbers of men to the dignity and value of natural knowledge. And I would ask you to remember, and especially the young men, that knowledge of man and his deeds and motives is a branch of natural knowledge. If we are to help mankind forward in this new era on which we have entered, we must gain positive knowledge, and we must vitalize it by contact with great characters and great events. We must get command of the sources of power in nature and then within ourselves, we must have courage and candor, fortitude, tenacity and imagination, and devotion; and the greatest quality of all is devotion.

THE COLLEGE GRADUATE AS AN ENGINEER.

By

Dr. Alex. C. Humphreys.

It is quite possible that this address of Dr. Humphreys is somewhat too abstract and difficult of comprehension for the average student: nevertheless a careful study of it cannot fail to enlarge the reader's mental grasp of the subject of engineering education. It will also give emphasis to the statements of several of the other authors, and will impress upon the student the importance of a number of special studies in engineering curricula.

The quotations from Dr. Eliot are classic and, therefore, worthy of serious consideration.

The business aspects of this address are especially commended to the engineer-student, as they constitute the most characteristic or special feature of Dr. Humphreys' system of imparting engineering instruction.

Editors.

THE COLLEGE GRADUATE AS AN ENGINEER.

By

Dr. Alex. C. Humphreys.

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Our progress in the industrial arts has of late been so marked as to raise the United States to the first rank as an industrial power. Our relative progress has excited earnest inquiry among the statesmen and educators of other countries to determine the causes therefor. It has come to be acknowledged that among these causes must be included technical education, and we have for a year and more been receiving visits from commissions and individuals from abroad charged with the duty of investigating our systems and methods. While among ourselves this subject has been receiving the attention it deserves, and manufacturers, engineers, and educators have been most active in its discussion, looking to the eliminating or minimizing of faults and the further development of the good points of the systems and methods followed, there are still to be found many high in authority who refuse to concede to technical education the position it deserves and who fail to see that the study of the subjects included in the engineer-students' curriculum may serve to broaden and cultivate as well as to make efficient.

I am sorry to say that I have more than once been obliged to listen to the applause called forth by attacks on technical education contained in addresses delivered before assemblies largely composed of professional educators. By those who thus assume an unfriendly attitude towards technical education it seems to be taken for granted that this special training is necessarily opposed to culture studies. No doubt some reason for this distrust can be found in the excessive specialization at one time to be generally found in our technical courses and still, unfortunately, to be found in some; but I contend that where this special training is wisely provided for only a necessary discrimination is exercised in the specialization and the result no more tends to produce narrow men than does the old B. A. course. I do not affirm that the best engineering course necessarily produces the cultivated man, nor can this be claimed for any course of study.

By those who elect thus to sit in judgment on the engineer, apparently it is assumed that he is necessarily engaged with material

things only and that it is reserved to those who more exclusively follow the humanities to take part in the higher things of life. By some the opinion seems to be held that the engineer is a man who confines himself to the occupations that require the constant wearing of overalls. Confusion exists in the minds of some as to the functions of the engineer as compared with those of the mechanic.

In setting before you the claims of the engineer as a member of a profession I have no intention of casting reflections on those who earn their living by manual labor. I hold that the first duty of every man is to be a producer so that he and his shall not be a burden upon the community and still further that he may contribute his quota to the common purse for the support of the Government and the support of those who, for one reason or another, are actually incapable of carrying even their own weight. Any man, be he cultured or uncultured, who honestly performs his duty in this connection need not be ashamed to look the world in the face.

Our views may vary as to our responsibilities with regard to the hereafter, but there should be no question as to the duty of first honestly and courageously meeting the present responsibilities of this life. Apparently there are those who hold that the present and evident duties can be neglected or wholly pushed out of sight that they may the more completely devote themselves to the contemplation of their responsibilities with regard to the hereafter.

If I am right in believing that the time we are permitted to spend on this earth is one of preparation and development for something higher, then nothing of the present can be neglected and the education of those who are to take part in the world's work becomes a solemn responsibility.

From this point of view it is unprofitable to make comparisons as to the relative importance of the several professions or vocations. All legitimate vocations are important, and the world's work, to be in balance, requires the honest, intelligent filling of all. Some produce in a material way; others produce through their imagination, and their product serves to uplift, encourage, and sustain those engaged in the more material callings.

The man who faithfully works to the limit of his powers and opportunities, no matter how lowly his vocation may be, rises superior to the man of greater or more refined powers and larger opportunities who does only a part of that of which he is capable. This may be trite, but my experience in widely differing lines is constantly showing me that this truth if recognized is not heeded and, as a result, the faithful worker is unfavorably compared with the brilliant idler.

But the engineer's vocation is not a lowly one. In the certificate of membership of the great Institution of Civil Engineers of Great Britain appears the following:

"A Society established for the general advancement of Mechanical Science and more particularly for promoting the acquisition of that species of knowledge which constitutes the profession of a Civil Engineer, being the art of directing the great sources of power in Nature for the use and convenience of Man."

God—or, if you prefer, Nature—has placed in our hands certain materials and forces. These must first be apprehended, analyzed, and measured; and here is the field of the scientific investigator, the man of research.

It is for the engineer to take the knowledge thus furnished to him by the men of pure science and apply it so as best to meet the wants of his fellow men. The engineer must have such a knowledge of the fundamentals of science as will enable him to apply efficiently the work of the scientist. Sometimes we find an engineer more richly endowed with scientific imagination, turning from the work of application to original research. Sometimes, yes often, the scientist is directed into new lines by the engineer's specific statement of the need for further knowledge; and again, the scientist frequently builds and corrects his theories on the practical experiences of the engineer. The tremendous advance made during the last twenty years in electrical science is a notable example of such collaboration.

No sharp line can be drawn between the man of pure science and the man of applied science. The engineer of today must have a general knowledge of science and he must have a full knowledge of and be capable of practically applying the laws of Nature in at least one little corner of the great field of engineering. For now it has come to pass that no man can hope to be an authority over the whole wide field of engineering.

The engineer-student today must be so trained in the fundamentals of science and so trained in Mathematics that he can *after graduation* quickly and safely further specialize within his specialty of engineering. In our colleges we cannot make engineers, but we can prepare the students to profit thoroughly and promptly by their opportunities in the school of practice.

The institution of which I have the honor to be President has for its title "The Stevens Institute of Technology," with the secondary title of "A School of Mechanical Engineering."

One might then suppose that our work would be found to be as closely specialized as is possible. A glance over the list of our Alumni

shows at once that our training has fitted our men fundamentally for quite different lines of engineering work. In this list we find officers of railroads, superintendents of iron and steel mills, electric light engineers, electric railway engineers, manufacturers of electrical apparatus, gas engineers, specialists in steam, marine engineers, designers and builders of various kinds of engines, hydraulic engineers, bridge builders, sugar manufacturers, refrigerating engineers, oil refiners, locomotive builders, superintendents of copper refineries, manufacturers of instruments, superintendents of paper mills, manufacturers of textile machinery, mining engineers, etc., etc. The same college course furnished to each of these men a solid foundation upon which to build the superstructure required for his selected vocation.

It is true that in Technical Schools this concentration on a single course of study is rather the exception. At the Massachusetts Institute of Technology, for example, the students follow the same lines for part of the course, and then they begin further to specialize as electrical engineers, mechanical engineers, civil engineers, naval engineers, mining engineers, architects, etc. But even where there has been this more definite specialization within the limits of the college course, a further specialization and training in detail is required after graduation.

Before considering a department of study which should be included in every engineering course, let me for a moment again refer to the question—Does the education of an engineer necessarily exclude culture studies? President Eliot, of Harvard, can be taken as a notable example of the man of culture. He is also an authority of weight on questions of education. I leave my case then in the hands of President Eliot, though I could call in to my support many others of the prominent educators of our country, notably President Butler, of Columbia.

I quote from an address delivered this summer by President Eliot before the New England Educational Association, published in full in "The World's Work" of August, and published in condensed form in "Science" of July 17th, under the title of "The New Definition of the Cultivated Man." I hope that by listening to these quotations some of you will be led to read the entire address.

"There are two principal differences between the present ideal" (of general cultivation) "and that which prevailed at the beginning of the Nineteenth Century. All thinkers agree that the horizon of the human intellect has widened wonderfully during the past hundred years, and that the scientific method of inquiry, which was known to but very few when the Nineteenth Century began, has been the means

of that widening. This method has become indispensable in all fields of inquiry, including psychology, philanthropy, and religion; and, therefore, intimate acquaintance with it has become an indispensable element in culture."

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"I need not say that within that century what we call science, pure and applied, has transformed the world as the scene of the human drama; and that it is this transformation which has compelled the recognition of natural science as a fundamental necessity in liberal education."

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"A second modification of the earlier idea of cultivation was advocated by Ralph Waldo Emerson more than two generations ago. He taught that the acquisition of some form of manual skill and the practice of some form of manual labor were essential elements of culture."

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"The idea of culture has always included a quick and wide sympathy with men; it should hereafter include sympathy with Nature, and particularly with its living forms—a sympathy based on some accurate observation of Nature. The book-worm, the monk, the isolated student, has never been the type of cultivated man. Society has seemed the natural setting for the cultivated person, man or woman; but the present conception of real culture contains not only a large development of this social element, but also an extension of interest and reverence to the animal creation and to those immense forces that set the earthly stage for man and all related beings."

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"Let us proceed to examine some of the changes in the idea of culture, or in the available means of culture, which the last hundred years have brought about.

1. "The moral sense of the modern world makes character a more important element than it used to be in the ideal of the cultivated man."

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2. "A cultivated man should express himself by tongue and pen with some accuracy and elegance; therefore linguistic training has had great importance in the idea of cultivation. The conditions of the educated world have, however, changed so profoundly since the revival of learning in Italy that our inherited ideas concerning training in language and literature have required large modifications. In the year 1400 it might have been said with truth that there was but one language of scholars, the Latin, and but two great literatures, the Hebrew and the Greek. Since that time, however, other great literatures have

arisen, the Italian, Spanish, French, German, and above all the English, which has become incomparably the most extensive and various and the noblest of literatures. Under these circumstances it is impossible to maintain that a knowledge of any particular literature is indispensable to culture."

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"The linguistic and literary element in cultivation therefore abides, but has become vastly broader than formerly—so broad, indeed, that selection among its fields is forced upon every educated youth.

3. "The next great element in cultivation to which I ask your attention is acquaintance with some parts of the store of knowledge which humanity in its progress from barbarism has acquired and laid up."

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"It is too vast for any man to master, though he had a hundred lives instead of one; and its growth in the Nineteenth Century was greater than in all the thirty preceding centuries put together."

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"Culture, therefore, can no longer imply a knowledge of everything. It must be content with general knowledge of some things, and a real mastery of some small portion of the human store. Here is a profound modification of the idea of cultivation, which the Nineteenth Century has brought about. What portion or portions of the infinite human store are most proper to the cultivated man? The answer must be—those which enable him, with his individual personal qualities, to deal best and sympathize most with Nature and with other human beings. It is here that the passion for service must fuse with the passion for knowledge."

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"We have learned from Nineteenth Century experience that there is no field of real knowledge which may not suddenly prove contributory in a high degree to human happiness and the progress of civilization, and therefore acceptable as a worthy element in the truest culture.

4. "The only other element in cultivation which time will permit me to treat is the training of the constructive imagination. The imagination is the greatest of human powers, no matter in what field it works—in Art or Literature, in mechanical invention, in science, government, commerce, or religion: and the training of the imagination is, therefore, far the most important part of education."

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"Contrast this kind of constructive imagination" (he has been referring to Zola's *La Bête Humaine*) "with the kind which conceived the great wells sunk in solid rock below Niagara that contain the turbines that drive the dynamos that generate the electric force that turns thousands of wheels and lights thousands of lamps over hundreds of square miles of adjoining territory; or with the kind that conceives the sending of human thoughts across three thousand miles of stormy sea instantaneously on nothing more substantial than ethereal waves. There is no crime, cruelty, or lust about these last two sorts of imagining. No lurid fire of hell or human passion illumines their scenes. They are calm, accurate, just, and responsible, and nothing but beneficence and increased human well-being results from them."

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"That great century (the Nineteenth) has taught us that, on the whole, the scientific imagination is quite as productive for human service as the literary or poetic imagination."

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"It results from this brief survey that the elements and means of cultivation are much more numerous than they used to be; so that it is not wise to say of any one acquisition or faculty—with it cultivation becomes possible, without it impossible."

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"On the other hand, is there any single acquisition or faculty which is essential to culture, except indeed a reasonably accurate and refined use of the mother tongue?"

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"There has always been difficulty in defining culture. In the past the definition offered was often narrow and insufficient."

The time had arrived for the statement of a new and broader definition of culture, and President Eliot opportunely met the requirement. I have therefore felt warranted in quoting at some length from his masterly address, for I know I may serve you best by practically forcing on your attention that which the pressure of other duties might influence you to neglect.

Now the question is do the courses of study offered by the best of our separate engineering schools and by our university schools of applied science sufficiently include culture studies as defined by President Eliot?

To-day the engineer should be trained in theory and in practice.

Such progress has been made during the last thirty years in technical education that it seems like quoting from ancient history to go back a half century. But we find that Prof. Rankine, of the University

of Glasgow in his "Preliminary Dissertation on the Harmony of Theory and Practice in Mechanics," first delivered in two addresses in the winter of 1855-6 and published as the preface to his "Applied Mechanics," pointed out the necessity on the part of the educated engineer, of a complete training in theory and practice; and that, no longer must the fallacy be held that there is "a double system of natural laws; one theoretical, geometrical, rational, discoverable by contemplation, applicable to celestial, aetherial, indestructible bodies, and being an object of the noble and liberal arts; the other practical, mechanical, empirical, discoverable by experience, applicable to terrestrial, gross, destructible bodies, and being an object of what were once called the vulgar and sordid arts."

Rankine closes his dissertation with these words:—

"Thus it is that the commonest objects are by science rendered precious; and in like manner the engineer or the mechanic, who plans and works with understanding of the natural laws that regulate the results of his operations, rises to the dignity of a Sage."

To those of you who are particularly interested in either pure or applied science, let me strongly recommend to you a careful study of this dissertation of Rankine's. The man of science and the engineer are often required to meet fallacies; on such occasions Rankine's Dissertation may serve as a safeguard from fatal error.

For many years there has been a contest, which has not yet entirely ended, between those who contend that to be practical one must not be theoretical, and those who contend that to be scientific one must not be practical. This contention has not always been so bluntly stated, but that is what is meant when some say—we do not want scientific engineers, we want practical engineers; and when others say, we do not want practical engineers, we want scientific engineers. Both of these parties have failed to appreciate that the engineer must be capable of practically applying scientific knowledge. Especially in the United States it is now coming to be generally appreciated that the engineer must not only know but he must be able to do.

Discredit has been brought upon the engineering profession because some of its members have not been sure of their theories before they commenced to apply them; because others have been credited with a scientific training while they were weak in the very fundamentals of science and mathematics; because others with a fairly complete knowledge of science and mathematics have been deficient in practical ability and experience; and because others have been unable or unwilling to appreciate that engineering *practice* must conform to commercial conditions and requirements.

Still another opportunity for unfavorable criticism by practical business men has been given by the lack of a proper disciplinary control of the students so often to be found in our colleges, with the result that not infrequently the employer finds it far more difficult to lick into shape the college graduate than he does the boy from the high school. The boy goes from the control of the school and naturally submits to the control of the office; too often the college graduate has been demoralized by four years of college license and so is unwilling to submit to office discipline. This can be corrected only when faculties and students recognize that the same laws are intended to govern those in the college and those outside, and that the breaking of the law cannot be excused on the plea that only a little fun was intended. While this criticism applies to some graduates of our schools of engineering, I believe it applies in a greater degree to other college graduates. This difference is perhaps accounted for by the facts that a majority of engineering students enter college with the definite purpose of preparing themselves for a selected vocation and having entered they are worked so hard that there is not much time or energy left for foolishness and lawlessness.

Undoubtedly our colleges have been also in part responsible for the discredit which has been brought upon the engineering profession through the causes first mentioned. In some cases the course of study has been too closely specialized, too much attention has been devoted to the details of technical training and too little to the fundamentals of science and mathematics and to the more general and more broadening studies. There has been too much of a tendency to stuff the students with facts when rather their reasoning powers should have been more thoroughly trained to apply principles to cases.

Now a reaction has set in, if we may judge from the public utterances of many of our prominent educators. If so, then we must see to it that we do not go to the other extreme by making our courses of instruction too broad and *too general* and so fail to give our engineer-students that special and exact training in the fundamentals which they certainly require before all else. We must above all things be thorough. Even in the interest of culture, there can be no advantage, on the one hand, in omitting this exact and thorough feature of the training nor, on the other hand, in so crowding the curriculum that the store of knowledge offered cannot, within the four years, be assimilated and systematized for use.

We must then resist the pressure constantly felt to introduce new matter into our courses. We must appreciate that many of the things thus pressed upon our attention are only new applications of the same

fundamental principles. If we decide that these newer applications are more important than some others already included, we must recognize the necessity for selection and we must eliminate the old as we introduce the new.

Every engineer-student should be given full opportunity to learn that for true success in his profession he must after graduation take up a post-graduate course of study, and that probably the best post-graduate course will be followed in connection with his work as a wage earner in some one part of the field of engineering. Engineering post-graduate work in college is only possible for a small minority and it is doubtful if the advantages outweigh the disadvantages in the case of the large majority. There are certain necessary things to be learned only by contact with the working world.

Nor need this later closer specializing be necessarily narrowing if the man has been previously broadly (not superficially) trained.

The training in the fundamentals of science and mathematics (the theory) should be constantly harmonized with the training in the laboratories and shops (the practice); and the connection between these two branches should be constantly emphasized by the work in the department of Mechanical Drawing, which can well be made a strong connecting link.

To these should be added one or two modern languages and as much as possible of the mother tongue and its literature. The study of English should be kept in mind in each of the other departments and should be finally kept prominently in view in connection with the writing of the graduation thesis, which should be a business-like report on some experiment, investigation, or construction. And the engineer-student should not be graduated until he has given proof in his thesis of the thoroughness and breadth of his training and of his ability to express himself clearly and explicitly.

Now let me refer to one other feature which in my opinion should be included in the curricula of schools of engineering. A failure to do so has been a fruitful source of distrust of the engineer on the part of the manufacturer and the man of business. I refer to instruction in business methods. I do not refer to such a superficial treatment of the subject as will enable young engineers more quickly to take up positions as salesmen of machinery and apparatus, but I refer to that broader training in business affairs which every man must sooner or later acquire if he is to be a leader.

I contend that even the man who is to stick closely to the technical side of his profession must know of the limitations and conditions under which his technical knowledge is to be made available for those who wish to buy his knowledge.

The engineer should know the principles at least of Accounting unless he is to be absolutely dependent for the record of the financial results of his work on the unchecked statements of a bookkeeper. Frequently cases arise in engineering work and in manufacturing where the accountant alone is not competent to determine whether the final result has created a profit or a loss.

We have only to think of the grave responsibility to others, perhaps innocent and dependent investors, to see that this brings in a consideration far above things material.

The daily press has lately shown us how the lack of a combination of business and technical training in the persons of responsible heads of industrial concerns has brought loss to many innocent people.

The early history of our United States railroads is filled with the records of financial disaster which might have been avoided if a combination of engineering knowledge and accounting skill had been exercised to produce correct statements of profit and loss which in turn should have prevented the impairment of capital by the payment of unearned dividends.

Then the engineer should be capable of following up in detail the records of shop cost. Further, he should be capable of outlining a system for the keeping of shop cost records. In some large establishments the keeping of shop cost is a matter of great complexity, and many a concern has been ruined because this fact has not been soon enough realized.

The engineer should be warned against the dangers to be encountered in the drawing of specifications and contracts; he should be taught that the annoyances and losses involved in lawsuits are most easily to be avoided by the exercise of care and skill in the writing of such papers, yes, and in the dictating of the routine correspondence.

In this connection may well be included in the engineering course some lectures in commercial law and especially the law of contracts—not with the idea that the student shall be encouraged to be his own lawyer, for this he should be warned against, but that he shall the better be able to avoid the necessity for a lawyer's services.

To give the student more interest in the study of English it should be constantly kept before him in the several departments that only through a fairly complete command of the mother tongue can he hope to make available the knowledge and training he is acquiring in those departments.

The engineer-student should also be shown that the preparing of correct estimates of cost is something which his employer or associates have the right to demand. Then it should be shown to him that in most cases such estimates can only be made where the correctness of past

records of cost can be absolutely relied upon. And it should be here again shown that the keeping of such records is something of more or less complexity and frequently not to be compassed by a man who is only an accountant or only an engineer.

The business man has been too often given the right to regard engineers' estimates with suspicion—and this has been because the engineer has been insufficiently equipped to meet reasonable business requirements.

Again, in this connection the engineer-student should be given some insight into the value of data and statistics and warned of the dangers to be encountered in their partial reading. It is the duty of the engineer to see that figures do not lie, and this can be done only by exercising every possible care in the collecting and the interpreting of data.

Again, the engineer, if he is to be a safe guide for investors of capital must be keenly alive to the fact that all kinds of plant depreciate and that to prevent impairment of capital this depreciation must be correctly measured and provision made to compensate therefor out of the annual profits; and that otherwise the capital is impaired. Here perhaps as much or more than in any other one direction does the training of the accountant need to be supplemented by that of the engineer, or vice versa.

The engineer-student should also be instructed as to the relative rights of capital and labor, and no effort should be spared in this and other connections to show him that the Golden Rule is the only rule to follow, even if he is not to rise in his motives above the plane of expediency. Capital today justly has cause for serious complaint against labor, but it is to be remembered that in the past there have been provocations offered to labor so that we may be reminded to avoid such provocations in the future. Into the hands of the trained engineers will in the future largely fall the management of our industrial properties; an examination of the alumni lists of our prominent schools of engineering will show how rapidly this is coming to pass. Under the circumstances, a great responsibility rests upon our engineering schools, for on the results of their work as found in the persons of their graduates will largely depend the building up and the maintaining of such a spirit of mutual confidence and good will between labor and capital as is necessary to the well-being of our country.

Those who are ready to criticize technical education in general are even more ready to criticize the addition of instruction in business methods as tending to make engineering less professional and more sordid.

A certain class of culture faddists, losing sight of proportion, argues that commercialism should be excluded from the higher institu-

tions of learning. Culture is to be admired and we are all prompt to render homage to the cultivated man who is also an active, intelligent and unselfish worker for good. But daily our experiences are showing us that there are men who having enjoyed full opportunities for culture have only laid on a veneer which when penetrated discloses selfishness and inefficiency.

No possible training can ensure against either open boorishness or culture-veneered selfishness.

But I contend that in adding instruction in business methods to the engineer-students' technical training we are increasing the chances of developing our students as all-around men. It is a decided step in the direction of culture if we can lead our subject to look at things from all points of view and especially from that of the other man.

It is right then that we should point out to the engineer-student how he can best do his whole duty to his employer, to his employees, and to the community.

It is right that he should be convinced, if possible, that he cannot be a law unto himself, that he must be a faithful and efficient servant, and that this can be done only when he conforms to legitimate business customs and requirements.

By reason of the faith that will be put in him primarily through his professional diploma he should be shown his responsibility to his Alma Mater.

Again, it is chiefly in connection with instruction in the business end of his calling that he can be warned of the temptations to which, if at all successful, he will be subjected: viz., to certify to statements which are known to him to be false or which he has not himself fully investigated; temptations to make incorrect estimates to induce the first investment of capital; temptations to "skimp" designs or construction to save a profit for himself; temptations to gain privileges or concessions by corrupting others; and many other temptations which are continually presenting themselves to the man whose special ability as an expert leads others more or less blindly to trust to his statements.

Again, in the discussion of such an apparently matter-of-fact subject as statistics or data there is the opportunity to impress upon the student the responsibility for seeing that figures are not permitted to lie, or still worse made to lie; that to ensure the honest employment of data constant vigilance must be exercised; that especially should the investigator guard himself against a too ready acceptance of facts and figures which tend to confirm him in preconceived opinions. And here the warning should be extended against the dishonesty of accepting and quoting any statement of opinion unless it is as carefully conditioned and safeguarded by the context as in the original expression.

So great are the opportunities for a man who has had experience in the fields of engineering and business to do good to engineer-students in this direction, so great are the opportunities to put before them high ideals of professional honor, that this branch of the work should only be entrusted to a man who has had these experiences and who has a real appreciation of his responsibility for the future welfare of those entrusted to his guidance.

Finally, I do not claim that such a course of training as I have briefly outlined necessarily produces the trained engineer and the cultivated gentleman, but I do claim that such a course *can* turn out such a product where the raw material offered is capable of such cultivation. And as far as cultivation is concerned nothing more can be claimed for any college course.

THE STUDY OF ENGINEERING.

By

Professor William H. Burr.

A book of this kind would not be complete without a specimen of the technical literature of Mr. Burr, whose fame as an engineer, a mathematician, a technical writer, and an instructor is world-wide. Unfortunately, he has written very little that is suitable for the Editors' purpose, most of his literary productions (barring his text-books) having been prepared for practicing engineers. This paper, however, is eminently suitable, dealing as it does with the broad field of technical education and the applicability thereof in numerous branches of activity closely allied to engineering.

Coming from such a high authority as they do, the teachings of this address ought to produce a convincing effect upon the reader's mind, and the elegance and force of the English used render the paper a model for engineering writing.

William Hubert Burr was born at Watertown, Connecticut, July 14, 1851, and was graduated from the Rensselaer Polytechnic Institute in 1872 with the degree of Civil Engineer. After four years of general practice, he accepted the chair of Rational and Technical Mechanics at Rensselaer, where he taught until 1884, when he took the position of Assistant to the Chief Engineer of the Phoenix Bridge Company, becoming later its General Manager.

In 1892 and 1893 he was Professor of Engineering at Harvard University, and since 1893 he has been Professor of Civil Engineering at Columbia University, at the same time attending to a large and important private practice as consulting engineer in various lines of construction. He has held and still holds many lucrative official positions in New York City, and he has served on several National Commissions of great importance, including two of those for the Isthmian Canal.

He is a member of the American Society of Civil Engineers and of the Institution of Civil Engineers of Great Britain, and is the author of numerous papers and several books on engineering subjects, all of which are regarded by the profession as authoritative.

Prof. Burr's career as an engineer is one of the most successful on record. In one feature it is unusual, for he has attained wealth as well as distinction.

Editors.

THE STUDY OF ENGINEERING.

By

Professor William H. Burr.

It is frequently stated and often earnestly contended that engineering is the youngest of all the professions. In some respects this is true, although it is not true as a fundamental statement. The modern science of engineering is of comparatively recent date, for it is scarcely more than a century since the operations of the engineer began to be based upon sound philosophical principles and it is even less than that since the calling of the engineer assumed full-fledged standing among modern professions. As a matter of fact during the past eighty or ninety years the engineering profession has made such rapid advances and has extended so broadly, that the corresponding educational demands for those about to enter it have not, to this day, been fully met. The numerous and vigorous engineering schools which have sprung into existence within the past fifty years have done and are doing excellent work. They have prepared thousands of young men for the creditable performance of their duties as engineers, but in too many cases not satisfactorily as professional men.

It is not intended by this observation to assume any position of superiority for those young engineers who have received a broad liberal education prior to entering the professional school, but simply to recognize the fact that there has often, in the past, been something materially wanting in the qualifications of engineers as a whole, resulting in the failure on the part of many in the community at least to recognize the full professional standing of the engineer. Fortunately this attitude of the public has largely disappeared, but it was only a few years ago when measures were discussed and proposed in the prominent engineering organizations of this country to induce or compel, so far as may be, a more adequate recognition of the value of professional services of engineers on the part of the public than had been the case up to that time. Some medical and law schools already require a liberal, college course of study as a qualification for entrance. The question has already arisen and is being seriously asked why those who are entering the engineering profession should not be required to possess at least as excellent educational qualifications as those who enter the professions of law and medicine.

The agitation of this question of engineering education has stimulated material advances in the educational preparation of young engineers for their life calling. A number of engineering schools already encourage the acquisition of a liberal education before beginning a course of study in engineering. Columbia University took this important step nearly fifteen years ago by prescribing probably the earliest six years' course of engineering study, the first three of which consist of work done in the college leading to the bachelor's degree and a subsequent three years in the engineering school leading to the engineering degree. This course of study is judiciously balanced so as to include all work given in the most advanced courses of engineering study in this country, the more elementary subjects of which are taken in the third year of college work and form part of the requirements for the bachelor's degree.

Such a course of educational training is of the highest value not only to those young men who contemplate following engineering as a profession, but for a far larger class who intend to pursue callings not wholly of an engineering character, although more or less affiliated with some lines of engineering work. This group of liberally educated technical men are fitted to find their occupations in many fields of manufacturing work, including such great industries as the steel and iron business, paper manufacturing in all its branches, the manufacturing of textile fabrics, manufacturing industries connected with the production of agricultural machinery and other commodities consumed in large quantities in agricultural pursuits, and other similar industries involving the manufacture and application of power, besides the broad field of contracting in its numberless ramifications in public works and corporate enterprises. Although the value of engineering study as a preliminary to these fields of industrial activity has occasionally been mentioned or even fully stated in some instances, its significance has not been appreciated to any sensible extent by the community as a whole. There is probably no direction in which engineering education can be made so widely useful to the modern community as in preparing its young men for this great diversity of useful callings.

It is obviously no error to consider that the main function of an engineering school is to educate engineers, and yet that part of its functions may in the future affect the minority of its graduates. Comparatively few engineers are required in the community as compared with physicians and lawyers. No member of any modern community can pass any great portion of his life, if that life is in any sense an active one, without requiring a number of times, and usually many times, the services of the members of those professions, but that part

of the public who require the services of an engineer at any time in their lives is comparatively small. It is a calling fundamental to the welfare and development of the community and one in which the rewards of earnest and well-directed effort are abundant, but the number of those who devote their lives to engineering specialties or to the practice of engineering in purely professional fields can never be relatively large. In one sense, obviously, this is advantageous, because it reduces the competition of the ablest and best qualified engineers to a simple matter compared with what it would be if the members of the profession were much more numerous. On the other hand, the number of young men throughout the country who are to follow callings in the great industrial and other corporate fields where the work to be done is, to a greater or less extent, of an engineering nature must always be great. They probably already constitute a majority of the executive and other officers of such industrial corporations, and it is a majority which will ever be increasing.

In fact, in any business, where there are questions of structure or machinery or applications of power, or of the development of power-producing installations, or of the creation of conditions designed to increase agricultural productiveness, or to manufacture raw materials from any of the great natural resources of the country into available products for consumption, it is imperative that those who conduct or in any way take substantial part in such lines of work in the most effective, economic and productive manner should possess those qualifications which come chiefly, if not only, through the study of engineering.

This general observation has already been more than justified in railroad corporations. In the near past the services of the engineer were required only in the construction of the road and the maintenance of the roadbed and motive power. All duties outside those of a structural or mechanical character were performed by business men in their executive capacities who possessed no engineering qualifications of any kind whatever; but that situation soon changed. It was found, and logically found, that the best executive or administrative officers of a great railroad corporation were, in the main, those who by education and experience had been engineers and consequently who, and who only, understood fully and thoroughly the character of the things which the railroad executive had to deal with. The broad questions of administration coming before every administrative railroad man and involving constantly, and many times in a thoroughly technical way, matters of an engineering character, can be satisfactorily settled so as to give to the corporation the highest efficiency by those only who are competent to pass judgment upon such questions. The functions

performed by every railroad corporation are largely of an engineering character and there is scarcely any question, even of a rate charge, which does not come back directly upon the engineering economics of construction and operation. In other words, the most thoroughly commercial matters which must be administered by the officers of a railroad corporation cannot be efficiently administered without an accurate knowledge of the engineering elements on which they are in the last instance based.

Precisely the same observations can be made with equal force regarding all branches of manufacturing, and they are of especial force in connection with the great industrial corporations of the country, all of which involve the administration of business interests depending for their efficiency, economy, and success upon greatly varied applications of engineering. Those applications include the construction, operation, and maintenance of power plants, a great variety of structures, applications of electrical engineering, mechanical engineering, chemical engineering, civil engineering, mining and metallurgy; and it is no longer possible to conserve such interests without technical knowledge and extended technical experience. While the actual doing of these things in every great corporate enterprise is intrusted to technical specialists, it is equally true that no administrative or executive officer of such a corporate organization can best conserve or administer the interests intrusted to him by virtue of his position without possessing the educational training and, frequently to a considerable extent, the experience acquired by engineers. While it is clearly beyond the capacity of any man to be personally familiar with all the technical details of any one of these various corporate industries, it is equally impossible, on the other hand, that he should be best qualified to discharge the duties of an executive position dealing with such technical interests without a fair knowledge of, and familiarity with, the fundamental principles which govern them, so as to know confidently what to require of the divisions or departments of the field of activity for which he is responsible. Some of the most signal failures in these corporate operations have resulted from the lack of essential knowledge on the part of administrative officers, just as the extended development and phenomenal growth of the most successful of them have been stimulated and directed by those who have had the requisite educational training and experience to direct and control intelligently and effectively the resources available for their purposes.

The study of engineering opens to those who pursue it the widest fields of industry and enterprise known to the modern world, and that study will never attain its full productiveness until it is so put before

the young men of the present time as to make clear the prominent features of its usefulness. It may be thought that too much emphasis is laid upon this application of engineering study, but it is done only for the purpose of calling attention to one of the most important functions of engineering education, the value of which has not yet been realized to any sensible extent even by those who are most active in promoting that field of educational work.

The qualifications demanded of engineers in all the extended fields of engineering work are vastly more complicated than in the early days of those engineers who have not yet reached even middle life. It is no longer sufficient that a civil engineer, a mechanical engineer, an electrical engineer, or a mining engineer and a metallurgist should possess just that amount of technical knowledge which will enable him to discharge the duties of any position which he may hold, purely as an engineer. He has, or may become not only an expert technical man, but also the controlling personality in many wide fields of professional work in which it is not only his duty to direct purely professional operations, but also to conserve varied interests depending upon those operations in such a manner as to secure the efficiency and success of an organization. In the discharge of these general or administrative duties, he loses in no sense his professional character, but he rather preserves it in a higher capacity and adds to it certain broad qualifications which can be best developed through his liberal education. It has become, therefore, almost or quite imperative that his educational training purely as an engineer should be preceded by the prior training of a college education.

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There is again another field of attractive activity which can best be entered through engineering study, and that is the wide field of municipal public works. This includes both the design and construction of all classes of public works, such as water works, bridges, roads and pavements, electric power development, electric lighting, harbors and docks, and other similar works, as well as the administration of those divisions or departments of municipal government whose jurisdictions include the various public works of large cities. There is no class of municipal officers who have given more satisfactory administration of these various public affairs than the commissions or commissioners who have been prepared for these public functions by engineering training and experience. The executive or administrative man is always sought whatever may be his calling. His capacities make him a marked man and the engineering profession has a full share of such leaders. Whenever these men have been put at the head of public works, departments, or commissions, they have rarely failed to leave creditable records be-

hind them. To such an extent is this true that on one occasion the late Hon. Carl Schurz dwelt upon it with marked emphasis in an address which he made in Baltimore. The engineer is not by educational training a politician; on the contrary, his whole habit of thought and work is to reach effective and honest results through which his purposes may be most efficiently accomplished, and that constitutes an excellent qualification for public service.

These official services which gain their marked efficiency chiefly through the training acquired by engineering study have developed largely during the past decade. In fact, within the past two years engineers engaged in connection with municipal public works have been appointed to high administrative positions in such great centers of business and intelligence as Boston, New York, Philadelphia, Springfield, Mass., and in a number of other large cities of the country. It is a field of honor and usefulness to which every engineer engaged in public works may properly aspire, and no candidate for such an office can possess any more effective qualification than that which he derives from an engineering education.

The influence of the study of engineering, therefore, is seen to reach far out in many directions which contribute to the welfare of the community, not only along purely technical lines, but also in a large number of great industrial fields and in the public service of the country.

THE MAKING OF AN ENGINEER.

By

M. J. Riggs, C. E.

Mr. Riggs is the Superintendent of the Toledo Branch of the American Bridge Company at Toledo, Ohio; and as such he has had a wide experience in dealing with young engineers. He is a graduate of the Iowa State College; and this address was delivered by him at his *Alma Mater* on the occasion of the dedication of its Engineering Hall in May, 1903. Portions only of the address are here produced—mainly those which deal with the necessity for absolute honesty in engineers of all kinds, ages, and conditions, from the embryo engineer just entering the freshman class of a technical school to the highest engineering authority in the land.

As the reader will perceive, Mr. Riggs treats of other ethical subjects than honesty, and all that he says is expressed in such a forceful, vigorous style that it cannot fail to produce a deep impression upon anyone who reads it at all carefully.

The Editors endorse heartily all that Mr. Riggs says; and they hope that his words of exhortation will long continue to aid in the betterment of the engineering profession by their influence upon its student members.

Mr. Riggs was born in Iowa in 1862. After graduating from the Iowa State College in the Civil Engineering course in 1883, he began work as draftsman in the office of Mr. S. M. Hewett of Minneapolis, Minn., who was at that time the Northwestern Agent of the Smith Bridge Company, of Toledo, Ohio. In 1887 Mr. Riggs removed to the main office of the company and there gradually worked up to the position of Chief Engineer. When in 1901 the Smith Bridge Company was absorbed by the American Bridge Company, he became manager of the Toledo plant, which position he still fills.

Judging by the character of this paper, it is to be regretted that Mr. Riggs has not been able to spare more time from his important work to devote to engineering literature.

Editors.

THE MAKING OF AN ENGINEER.

By

M. J. Riggs, C. E.

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This leads me to the statement of what I believe to be the highest purpose to which this fine building and equipment, together with the best efforts of all the professors in the engineering courses, should be dedicated, that is, briefly, to the building up of true men of strong character, breadth of view, and right purposes in life from the great abundance of raw material which lies scattered in your villages and on your farms all over this good state. When you graduate men of this stamp from your engineering courses you will have done your part toward making them first class engineers.

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When you look over the field and note what is being done and what is still to be done in the way of taking the forces and materials of nature and converting and using them to supply the world's needs, to build up society and to help along our best progress and development, you will find that there is plenty of work to be done, and that the engineer is the man who can and should lead and direct the doing of it, and let me say here that for the doing of this work the engineer receives ample reward. From the financial standpoint the efficient and capable engineer receives as much compensation, perhaps, as he would in any other profession or business. His best pay, however, comes from the work itself. There is a great satisfaction in doing things, and the successful accomplishment of any engineering work is a pleasure.

In these days the engineer is the man who is turning the world upside down, and I know of nothing finer or more satisfactory than the building of a Brooklyn bridge, the building and equipment of the Northwestern railway, the development of Niagara waterpower, the reclaiming of one-half of one of our large western states through irrigation, the completion of a Chicago Drainage Canal, the building and equipment of a modern rapid transit railway system such as is now being done in New York City, or the putting into successful operation the large steel mills of the Carnegie Steel Co., at Homestead, Pa.

If the engineer is to carry on successfully this great work he must be a first class man, he must be honest. He deals with forces and

principles which are unvarying and which of themselves tend to make him honest. He must be honest to himself and to his work. Any violation of these well known laws of nature will certainly make itself known and result in expense and disaster. He must be honest with his client or employer since he is put in trust of great interests both financial and material, and if he is to have the confidence of those for whom he works he can only have it by strict integrity and attention to business.

There is probably no place in any profession or business for the dishonest man, but of all the professions of which I know, that of engineering has the least room for such men. On the whole, I believe engineers as a class are usually honorable. I have known a few of the opposite kind and have never known one to succeed and maintain any position whatever.

The engineer must be energetic. His work is to get things done. He receives his pay and holds his position because men with means want to invest it with the idea of prompt returns. There certainly is no place in the engineering world for the lazy man. It is not how long will it take, but how quickly can it be done and how well, not how little can be accomplished today but how much, not half way service, but the very best that is in one.

The engineer must be a man of broad view. He has large things to do in every part of his work, large undertakings to be carried out, large investments of capital to be properly expended; and no small man can do these large things well. For this reason I think his training at school should not be narrowed down to a specialty, but that he should have a broad culture, one that will tend to help him in these lines and to make him fit to do what he must do in life if he is to succeed.

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The engineer must keep up with the times, he should not be lazy mentally, he ought to keep fully posted as to what is being done in a general way along engineering lines, and he should have a much better and more intimate knowledge of his own particular line. This he can do by keeping his eyes open and always being quick and ready to adopt any methods which may be better than his own. He should take and read carefully three or four of the leading engineering papers which are published and which are doing an excellent work for the engineering profession. He should belong to the local and national societies of engineers in his line, and should keep in touch with brother engineers which his membership makes possible.

Lastly, the engineer should be a good man. The qualities which I have outlined necessarily make him a man of power, of strength, and of influence, not only with the men with whom he works but also in

the community in which he lives. These qualities cannot but make him a leader in social and public life.

A man with all this inherent strength has no business to lessen it and curtail his usefulness and influence by not being a man of good morals, and by not using this strength to build up and help other men. There is no reason why the engineer should be blind on the moral side and every reason why he should be the opposite. I have little patience with the cob pipe, cigarette smoking, beer drinking engineer and I believe no one else has, and I also believe that the brightest man cannot succeed in the engineering profession who is not also a good man and who is not letting his influence for right be felt by his associates, friends, and neighbors.

I have carried for some years in my inside pocket some verses written by Maltie D. Babcock which I get out and read occasionally. The sentiment has helped me and I give the first verse to you now.

"Be strong, we are not here to play, to dream, to drift.
We have hard work to do and loads to lift.
Shun not the struggle, face it.
'Tis God's gift."

AMBITION.

By

Winder Elwell Goldsborough, M. E.

The following extracts are taken from an interesting and spirited address made in 1906 by Mr. Goldsborough (then Vice President of the American Institute of Electrical Engineers) to the students of the Thomas S. Clarkson Memorial School of Technology.

Mr. Goldsborough's definition of work as being "something agreeable to do" is a good one and should be remembered and appreciated; and his approval of the "rolling stone" receives the unqualified endorsement of the Editors.

Mr. Goldsborough was born in Baltimore, Md., October 10, 1871. He was educated at Wrights' University School, Baltimore, and Cornell University, graduating from the latter in 1892 with the degree of M. E.

In 1892 and 1893 he was employed as electrical engineer by the Colliery Engineer Company, Scranton, Pa.; and in 1893 and 1894 he occupied the chair of Electrical Engineering in the University of Arkansas; afterwards he held the same position for eleven years at Purdue University. Resigning from teaching in 1904, he became Business Manager for J. G. White & Company of New York and London, holding the position for three years. Next he became Vice President and General Manager of the Denver Reservoir Irrigation Company for two years, then General Manager of the Laramie Water Company, and finally President of the Goldsborough Company, civil, mechanical, electrical, mining, hydraulic, and irrigation engineers.

He was Consulting Engineer to the Edison Electrical Illuminating Company, Baltimore, Md., in 1894 and 1895, and was Chief of the Department of Electricity at the St. Louis Exposition from 1902 to 1905.

He has risen rapidly in his profession and has held many positions requiring the greatest executive ability and the exercise of thorough technical training and knowledge.

He has read papers before prominent scientific and engineering societies, and has contributed articles to the leading scientific and engineering journals. He is an inventor with four U. S. patents to his credit; and his research investigations have included arc lamps, electrical machinery, and transformers.

He is a member of a number of the leading technical and scientific societies of America and England, and has been decorated with the Order of the Crown of Italy. He has traveled extensively, including a trip to China.

In respect to the address from which the following extracts were made, Mr. Goldsborough writes, "It so happens that much of what is contained in my paper I have used as a subject of talks given to senior students during the spring of their last year in college. Upwards of five hundred young men have been talked to along these lines, and out of that number a considerable percentage have found the advice given them of sufficient value to tell me voluntarily on their return to college, after they had been out at work a few years, that they had found the said advice of great assistance to them and had put it in direct practice with much benefit in the work that they had had in hand."

Such being the case, we hope that our readers will pay due attention to the counsel given in Mr. Goldsborough's paper.

Editors.

AMBITION.

By

Winder Elwell Goldsborough, M. E.

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We have a great misconception of what "work" is. When I was a boy, work meant discomfiture to me. I always heard work or labor spoken of as something that no one wanted to do.

Now, there are various definitions to be given to work, and the generally accepted definition of it is wrong. To my mind work is any agreeable and at the same time useful thing which a man has to do—the thing which he wants to do. It makes no difference what that thing is. If you are kept from "work" or tasks which you wish to perform by the obligation resting upon you to attend social functions, then these social functions become hard to endure. Many times a social function is a real bore, and there is no pleasure in it.

But, are there many of us here who have not felt the thrill that comes with the perfection of some one thing in which we have our heart? What young engineer, after he has created through his plans, designs, and work, a large engineering plant, would be willing to be absent from the starting up of that plant for any social function or any pleasure of field or sport which you could offer him? It is the essence of his success. His life blood has gone into the plant. It is a creature of life and being to him. And he would not give up the pleasure of being there; of working all night; of experiencing any discomfort to make that plant a success, for anything else you could give to him.

It is not the money, it is not the gain, which makes men in this country. America has been accused of being a country in which only gain is sought. That is not true. I have come in contact with too many of our men; I have seen too many of our boys; I have had them work too close to me ever for one moment to think that the dominant idea in the brains of our men and boys is money.

There are many things which a young man has to learn if he would succeed; and all of us want to succeed. If we could only, when we start out, have the knowledge of the ways and methods of mankind that we acquire in later years, it would be very valuable to use. We can't learn those things by having them told to us, because they somehow

slip away. If you visit an engineering structure and study it, you can always carry it in mind and remember it and have it as a direct asset; but if you only learn of it by hearsay, you may or may not be able to retain a memory of it. And so it is with experience. We must learn it at first hand. We must acquire it for ourselves. Then why should any young man be willing, during two or three or four years of his life, to stay in one shop and learn but one thing, when there are so many things to learn?

I once was conversing with Dr. Robt. H. Thurston. I had been out of college about three years, and in talking over the situation with him I apologized because the old saying "A rolling stone gathers no moss" did not seem to be exemplified in what I had been doing, as I had changed my position several times in the three years. He said "Don't worry about that. A rolling stone is the only one that gets polished." That set me to thinking. If the rolling stone gets polished—if you want a high polish, you have to roll a good deal.

So the thing for a young man to do is to get out in life and to learn all he can in one position, and then, as soon as he has acquired the better part of the knowledge of one—he is young—he ought to break off, and get another place, even if he has to begin all over again. Because—think of the experience he is going to get in the new place, the new problems he is going to have to solve; and he will be twice as good a man when he has acquired the new experience.

Make trouble for yourselves, or at least what the world calls trouble; and with deliberate aforethought, if need be. Change conditions around. You have but so many years to live. And before you are thirty years old you must acquire a good deal of information about the ways in which business is, and can be, done. You note that a certain man has consolidated a number of properties and thereby accumulated great wealth. How was that man able to do it? Once that man was in the same position you are. How did he find out how to consolidate properties? By going and consolidating something. And he built and he built, and he consolidated bigger things, and by and by he became a multi-millionaire—and you wonder how it all happened. Simply because that man had the energy to go and find out the ways of doing these things and then to do them, and not necessarily, at all, because he had the means at hand with which to do them. No man who has attained to fame or to wealth by his own work, has attained to it except with much the same foundation and much the same opportunity that you have.

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THE TWENTIETH CENTURY ENGINEER.

By

Dr. Henry S. Carhart.

This address was delivered by Dr. Carhart at the dedication of Pasadena Hall of the Throop Polytechnic Institute, Pasadena, California, in June, 1910; and it was published in the issue of *Science* of July 8th of the same year.

Dr. Carhart in this paper gives much information of historical interest, treats of a number of ethical matters, and offers a great deal of valuable advice to engineering students; hence it is here reproduced in full in the hope that our readers will reap much benefit from its perusal.

Dr. Carhart was born at Coeymans, N. Y., March 27, 1844. He studied at Wesleyan University, from which institution he received the degrees of A. B. in 1869, A. M. in 1873, and LL. D. in 1893. He studied also at Yale, Harvard, and Berlin. From 1872 to 1886 he was Professor of Physics at the Northwestern University, and from 1886 to 1909 he occupied the chair of Physics and Electrical Engineering at the University of Michigan. Since 1909 he has been Professor Emeritus there.

In addition to his professional work, Dr. Carhart has done considerable consulting engineering, mainly in the line of electricity. It was he who inaugurated and developed to its present state of high efficiency the electrical engineering course at the University of Michigan. He belongs to a number of technical and scientific societies of the highest standing both at home and abroad, and has been President of the American Electro-chemical Society.

During his long career he has often been honored by being chosen as delegate to expositions and congresses in Europe and America.

He is the author of numerous important technical and scientific papers in American and European Journals and of the following standard books: "Primary Batteries," "Elements of Physics," "University Physics," "Electrical Measurements," "High School Physics," and "College Physics."

Concerning the high character of Dr. Carhart's services at the University of Michigan, we quote the following closing paragraphs from an address by Geo. W. Patterson, Ph. D., delivered upon the occasion of Dr. Carhart's retirement from active service there.

"The debt of the University to Dr. Carhart is perhaps equally founded on the executive ability shown in the development of his own and her daughter department (electrical engineering) and also his great success as a teacher of men. How seldom is it that we find a man a great teacher and at the same time a productive scholar of world wide fame! His pupils will always remember his clearness as a lecturer and the uniform success of his experiments; but more than this, they will always be conscious of the impress that as a man he made on them.

"And then to us who have been fortunate in knowing him, there is the indescribable charm of good fellowship and personality which we shall not lose while he is among us, though he has laid his University duties down. May he live long to enjoy his rest from University labors and to prosecute his researches in old but ever new fields."

Editors.

THE TWENTIETH CENTURY ENGINEER.

By

Dr. Henry S. Carhart.

> It is essential to develop industrialism,—to train men so that they shall be engineers, merchants—in short, men able to take the lead in all the various functions indispensable in a great modern civilized state.

Such was the recent utterance of a distinguished American traveler in an address at the ancient Moslem University on the banks of the Nile. It reflects the sentiment prevailing in America today. Mr. Roosevelt held up as it were a mirror to the Egyptians, that they might see in it the reflection of American conviction relative to education. The underlying thought is, as he expressed it, that

> There has always been too great a tendency in the higher schools of learning in the west (the occident) to train men merely for literary, professional, and official positions; altogether too great a tendency to act as if a literary education were the only real education.

The foundation of healthy life in the state is necessarily composed of the men who do the actual productive work of the country. Among these producers the engineer is pre-eminent. Without him in the complex commercial life at the present, capital would lie idle, colossal manufactures would shrink to individual industries, the development of resources would cease, the earth would no longer contribute as now to the wealth of nations, and society might eventually relapse into the relation of the feudal baron and his retainers of the middle ages.

The engineer is now more than ever before an essential factor in affairs. Engineering information and technical skill are in demand in many fields not heretofore requiring them. What manner of man is this present-day engineer, whose existence and work are so vital to the higher interests of society? What are the intellectual qualities that fit him for his high office, what the aptitudes that qualify him for leadership, what the supreme test of his fitness to bear on his shoulders some of the burdens of organized civil life and to lead the way toward still higher achievements? Finally, what style of intellectual training is best suited to fit him for the prodigious problems awaiting solution at his hands?

It is not necessary, even in this presence, to refrain from saying that the tvpe of man. whom we are about to survey in his highest

ethical and intellectual character, is not an artisan, a motorman, nor even an engine-driver, as useful and honorable as these callings are. Nor is it manual training or manual dexterity or mechanical skill that constitutes his claim to recognition as an invaluable contributor to progress in the twentieth century. He is rather the masterful man who unites oceans and revises the paths of commerce; who levels hills and removes mountains if they chance to be in his way; who changes the course of rivers or sends them through tunnels to generate electric light and power and to convert deserts into fruitful fields.

If modern industry demands combination and the massing of capital, combination requires the services of large-minded engineers as managers. When Cecil Rhodes appealed to the Rothschilds for capital to form the De Beers Diamond Mining Company for the purpose of uniting all the diverse and independent claims of the Kimberley diamond field, he was assured that money would be furnished on condition that they be permitted to place in charge their mining engineer as manager—Mr. Gardner Williams, who hailed from the great state of the Golden Gate. Mr. Williams substituted for the open working of the diamond mines his method of mining by vertical shafts and horizontal tunnels into the core of the precious "blue-ground" filling the volcanic pipes, which have yielded uncut diamonds to the aggregate value of more than $500,000,000.

When the great gold-bearing reef at Johannesburg, the richest gold mining district in the world, needed a controlling genius to direct the Kaffir mines, it was John Hays Hammond, another American mining engineer, who dictated the engineering and mining policies of the Witwatersrand. Hammond adapted the method of mining the ore and winning the precious metal to the conditions existing in that great outcropping reef, forty miles in length, with the result that a low-grade conglomerate has yielded millions of gold with a fair profit to the shareholders. In large enterprises of this character success or failure turns on the trained intellect, the executive ability, and the comprehensive grasp of the controlling brain at the head.

There is no rainfall in Egypt. The burning, wind-driven sands forever face a cloudless sky. On half the city of Cairo no green thing grows and flourishes. Mosques and the splendid tombs of the Memlook sultans are surrounded by drifting sand. But for the yellow flood of Father Nile the whole of its fertile valley would be as parched as the sands about the great pyramids of El-Geezeh. I have seen the river in flood, when its turbid water stretched for miles beyond its banks to the rising ground at the feet of the Sphinx, enriching, irrigating, and insuring a bountiful harvest to the stolid husbandman, who still prac-

tices the methods consecrated by centuries of use. Nature has done much for Egypt; engineering has done no less. The *barrage* at Cairo and the stupendous dam at Assûan conserve the rich tepid flood of the Nile and pour it in golden streams over a million acres of fertile sugar-cane and cotton land. Instead of a burning, barren waste, the land of the Pharaohs has become more than ever before in history a garden of the gods. Egypt may hate England, but to Sir Colin Scott-Moncrieff, an English engineer, who raised the *barrage* at Cairo and built the Assûan dam, she owes more than she ever did in ancient times to Ramesses II

Across the Firth of Forth in Scotland stretches a massive iron bridge with two main cantilever spans, each longer than the famous Brooklyn bridge. They were pushed out horizontally from two cantilever shore arms without scaffolding or false works, and with the roadbed soaring 300 feet above the water of the Firth. M. Eiffel declared that it was in comparison an easy task to build the Eiffel tower nearly 1,000 feet high, because it is vertical and stands on a firm base; but to push out such a tower horizontally 300 feet above an arm of the sea, and to balance it during construction on the top of a tall pier, was infinitely more difficult and hazardous. This hazardous feat the late Sir Benjamin Baker accomplished, and over his monumental bridge 400 or 500 trains now pass daily. It was this same plain but resourceful engineer who designed the cylindrical ship that transported Cleopatra's needle from Alexandria to New York.

These daring, resourceful, and intrepid engineers are examples of those who did their work for the most part in the last century. They are typical of a class who achieved fame and accomplished great things with but little help from the universities. They learned their lessons in the great school of experience, and arrived at success despite the lack of the early opportunities now open to the aspiring engineering student. They were not narrow specialists, but men with the broad intelligence to consider a new and difficult problem from all points of view, and to employ for its solution any method which their intellectual resources could command. They were not mere copyists, who read nothing beyond the headlines of their copy-books, nor yet mere imitators content to cull from the products of genius those that could be adapted to the problems in hand. They were rather the creators, whose edifices, built on the foundation stones hewn by others, have risen above the horizon for many lands.

If we inquire somewhat more minutely into the qualities that make for leadership in engineering, we shall find that thoroughness, originality, and the habit of making all mental acquirements one's own

are essential. Originality is a gift, but it may be cultivated; the two other qualities are certainly within the reach of every young man with normal mental endowments. The habit of going to the bottom of every subject investigated instead of contentment with a superficial examination is one to be assiduously cultivated. Each essay in concentrated effort makes mental fitness for still deeper levels of penetration.

Thoroughness is associated with sincerity in the conduct of public works. The greater undertakings which an engineer is called on to design and execute are not the ephemeral structures, made of "staff" and designed to house an international exhibition; they are for posterity as well as for his contemporaries. Noble examples of thorough and sincere work have come down to us from ancient times. One allows the eye to follow with admiration the long lines of aqueduct stretching across the Roman Campagna, in large part still standing, though gnawed for centuries by the tooth of time. In the Forum in Rome is an opening into which one may descend to the uncovered Cloaca Maxima, or great drain of the imperial city. It was built long before the Christian era and was old when Paul suffered imprisonment in Rome and execution outside the gates. Huge rectangular blocks of tufa lie in perfectly level courses without cement, and through this great drain today runs a stream, like a small river, on its way to the yellow Tiber. This was honest work and the twentieth century engineer might well imitate it.

Then the proper assimilation of one's information is no less essential than thoroughness. It is not uncommon to observe a sort of aloofness of a man's mental attainments with respect to his powers of practical achievement. He appears to have put his acquisitions in a safety vault and lost the key. His intellectual equipment is for adornment and not for use. His collection resembles some collections of physical and engineering apparatus I have seen, well arranged from the point of view of a museum, but never used. A certain college janitor once complained in explanation of his ill health that his food didn't "suggest." This state of health is characteristic of the mental dyspepsic, who does not digest his intellectual pabulum, nor does it "suggest" any way in which it may be turned to good account.

Another quality of the great engineer is daring. The mythical Darius Green had it, but his daring was not coupled with the propelling power of an internal combustion engine; hence his story only adorns a rhythmic tale. His flying machine was not a forerunner of the aeroplane. Without this quality of daring developed to an astonishing degree the Wrights would not have amazed the world by their sustained flights, Bleriot would not have soared aloft across the Eng-

lish Channel, Paulhan would not have flitted from London to Manchester, nor would Curtiss have followed the silver line of the noble Hudson from Albany to New York. These men are representative enthusiasts of the aeroplane, whose intrepidity has made possible the navigation of the air.

The history of the first Hudson River tunnel at New York is one of repeated accidents, of many failures, and of final success. During one of the periods of inactivity and when the enterprise halted near complete failure, Sir Benjamin Baker was brought over from England as a consulting engineer to give advice to the company. The air caissons were in a dangerous leaky condition, but Sir Benjamin must himself go down to make an examination. So he called for a volunteer to accompany him. An Irish laborer stepped forward and indicated his willingness to go. Together the two descended into the pneumatic caisson. The inspection completed, imagine their dilemma when Sir Benjamin discovered that their return was cut off by the leaky condition of the air locks. The eminent engineer said to his Irish companion that there was only one thing to do; they must bring mud in their caps, plaster over the cracks, and stop the leaks. The expedient was happily successful and the two escaped into the upper air. I heard Sir Benjamin tell the story to illustrate the devotion of the Irish laborer. After they were safely out Sir Benjamin said to his companion in danger, "Pat, why did you risk your life to go down into the caisson with me?" Pat replied, "I'll tell you sir. Do you remember when you were building the Forth bridge and the foundation of one of the piers was going in, and you were in the pit inspecting the work, that Mike McGinnis, Dan O'Leary, and myself were dumping stone into that same pit, and dumped a load without seeing that you were below? But as good luck would have it, sir, you were not hit. And what did you do sir? You just turned an eye up to see who had dumped the stone, but you said nothing, sir, and we were not told to go to the office for our time. And now here I am, sir; I endangered your life once, and it was only fair for me to take a risk for you when you needed it." Ah! how many unrecorded deeds of devotion stand to the credit of the common laborers, who have risked their lives, and, alas, too often lost them, in carrying out some great enterprise for the public. The engineer at the head must be the intrepid leader of intrepid men.

The engineer who devises and executes public undertakings of magnitude must always be prepared for the unexpected and therefore must be resourceful. It is not unusual to encounter difficulties not anticipated. These must be surmounted or failure is inevitable. A solution must be found without delay or great interests are imperiled.

Swiss engineers are at present constructing a short-cut railway line between Lake Thun and the mouth of the Simplon tunnel. It includes a long tunnel through a mountain range. Two years ago, after this had been driven forward about a third of the whole length from either end, the cut from the south side was unexpectedly and suddenly driven into a deep cleft or fault filled with soft mud and ooze and forming the underlying filled bed of a mountain stream. Twenty-five men were overwhelmed and lost their lives. Now a tunnel could doubtless be pushed through soft material of this nature, but there was no foundation on which it might rest. Was the enterprise therefore abandoned? By no means. Starting back a short distance from the uncovered fault, the engineers ran a curve into the heart of the mountain behind the obstruction; this will join the two straight portions already completed.

A similar fault 900 feet deep and filled with sediment has been found under the bed of the Hudson at the Highlands where the new aqueduct crosses the river. Since this is an aqueduct and not a viaduct, a different solution is possible. The tunnel is to be carried under the river as an inverted siphon with the vertical legs nearly 1,000 feet deep. If one can not remove or overcome an obstacle, one may at least go around or under it.

These enumerated qualities which make an engineer fit are intellectual. There is still another which is a supreme test of fitness for public service. It is the moral quality of honesty. Failing in this, there is no compensation. Intellectual honesty includes the characteristic of sincerity, to which allusion has already been made. Moral honesty is no less essential in any age, but especially so in these days of uncovered bribery and graft. The honest engineer's opinions are not for sale to the highest bidder. He is entitled to compensation for his judgment and his decisions, but they can not be purchased, a distinction with a marked difference.

There has never been an age when capable and honest engineering talent was more in demand than in this new century. The present-day problems in great cities, incident to the rapid introduction of new methods of transportation, of lighting and power, and of communication, are insistent for solution. They are almost hopelessly entangled with vested rights, and with class privileges, which have been recklessly given away in the past, or handed over for a secret and vicious consideration on the part of those incidentally in power. Civic bodies and public-service commissions, thanks to such heroic leaders as Governor Hughes, are now giving expert attention to the solution of these economic problems in cities, aided by the highest engineering talent that good compensation can command. New York, Chicago, and now Pitts-

burg are the subjects of study by such commissions, constituted either by private appointment or by legislative enactment. The engineers studying these problems must be clean-handed and honest to the core. This kind of public service is in its infancy, and the future is certain to furnish more of it for competent and clean engineers.

I have sketched rapidly the salient characteristics of the modern engineer required for the larger problems of an age in which industrial development proceeds with astounding rapidity. It is too much to expect these qualities to be displayed in a marked degree by young men just entering upon a course of study leading to a degree in engineering. It is not mere possession of such qualities that ensures success, but the marked development of them. There are boys enough of sterling character, with originality, thoroughness, nerve, and resourcefulness in the directions in which the interests of youth lie. It is the office of the enthusiastic teacher to develop the possibilities of a promising boy, to stimulate the growth of those traits that especially need nurture, and to encourage the power of initiative and self-reliance. And he shall have his reward. It comes not in the way of pecuniary compensation, but in that sweeter award of appreciation and gratitude on the part of those whose regard in after years counts for more than mere passing popularity. No greater delight comes to the worthy teacher of large experience than the success of those in whom he has taken a personal interest, and for whom he has been able to open the door of opportunity.

It is pertinent now to touch on the style of training best adapted to develop the qualities that distinguish the eminent engineer from his less fortunate fellows. What shall be the philosophy of his treatment educationally for the conservation of his undeveloped resources and the reclamation of his arid areas? These are serious issues for thousands of ambitious students who stand on the threshold of their young manhood.

The recent trend of affairs has shown too pronounced a tendency toward undue specialization in engineering practice. It is not enough that instead of the two traditional divisions of engineers in olden times, the civil and the military, there are now in practice civil, mechanical, mining, hydraulic, electrical, telegraph, telephone, sanitary, chemical, electro-chemical, and illuminating engineers, but the enthusiasts in these several lines are insisting that their specialties be assigned a seat in the circle of the engineering curriculum. This granted, the young collegian has either a narrow training that reduces him to the grade of an artisan, or the instruction given him is so superficial that it never strikes root and never reaches down to stir his subconscious powers. It may be sufficient for the practiced eye of a Paulhan to get a vivid impression of

the salient features of a landscape from the window of a railway carriage to serve as a guide in an aerial flight over the same region; but the young engineer, who gets a flitting view of the whole field of current engineering practice, from the moving-picture show of a lecture-room lantern screen will have only a sorry preparation for sustained flight when he attempts to rise by the power of his own enginery.

Instead of a panoramic view of engineering practice, an interested public has a right to demand training in fundamentals and the elimination of ephemeral details that constitute a current art and not a body of permanent principles. The older culture course has its humanistic studies, consecrated by centuries of use, and a body of trained experts as teachers, who are not often drafted from institutions of learning by the superior rewards of professional life. Pure science also has its settled subjects of study—its languages, its higher mathematics, and its circle of related sciences. Then too the scientific worker who has insight and becomes a discoverer enjoys a superlative satisfaction denied to men who never add to the sum of human knowledge as the results of research.

In contrast with these old-established courses, those in engineering are still indeterminate and lack a certain coherence which is the product of age. Shop work has too often been exalted above language, and laboratories have been established in imitation of a factory or a central power station. The fundamentals for general culture have been pushed aside by the onrush of machinery, and a young graduate must be able to run a steam engine and take an indicator card, even though he can not write a straight English sentence or dictate a business letter worthy to go on a post card.

Too much stress can hardly be placed on the necessity of thorough instruction in English. It is a common impression among the young that the study of one's mother tongue is a waste of time. There never was a greater fallacy. Psychologists tell us that a speech center has to be formed and developed in the brain. So far is human speech from being intuitive and automatic that we acquire it only by continuous and incessant effort. There is no tool used by the human mind requiring more polishing and taking a finer finish. Language is not an inheritance, but an acquisition. It may resemble on the one hand the crude spears or assegai of the South African Kaffirs, or on the other the flexible incisiveness of a polished Damascus blade. American college students have less facility in the use of idiomatic English than have students of the same age in the English universities. When one listens to the limpid and expressive English of an Oxford senior, and notes his large vocabulary and his facile use of it, as compared with the senior in an

American college, one is prepared to admit the propriety of the distinction often drawn on the continent between English and American.

The engineering student should have sufficient acquaintance with the best masterpieces in English to give him a taste for the highest types of English prose, and enough practice in writing themes to secure for himself a clear and expressive style of composition.

The opinion of eminent engineers on the pressing need of a better use of English on the part of members of their profession is the best evidence of the neglect of instruction in English in engineering courses in the past. The acquisition of a clear, terse style is urged by them on the ground that an important feature of the modern engineer's duties is to make reports on various phases of engineering undertakings. These reports are an index of the man, and if they are defective in form or finish, the natural conclusion is that he is also deficient as an engineer.

It is scarcely necessary to insist on thorough courses in physics and mathematics as fundamental subjects for all engineers, though the former has often been pushed aside, with barely time enough for instruction in the merest elements of the subject, notwithstanding the fact that engineering is largely applied physics. A civil engineer at the head of that department in a large technical school recently admitted that engineering students should take a course in light because of their use of optical instruments in surveys and locations, but he expressed the opinion that they had no use for the study of sound. And yet the abatement of serious and unnecessary noises in large cities is already the avowed object of several voluntary organizations. Any observant traveler, who has occasion to patronize the New York subways, will readily admit that some attention to the avoidance of noise on the part of the civil engineers who designed the subways would have been of great benefit to the patrons of that wonderful artery of travel. When the London Central was first put in service seventy-five feet below the surface, complaints and suits at law were numerous on the ground of serious vibrations transmitted to buildings overhead. These vibrations have largely been eliminated by reconstructing the electric engines to prevent their pounding the rails. Such facts as these the modern engineer would do well to heed.

An engineering course should include instruction in history and economics. The great civic and economic facts of the larger world should be a part of the engineer's outfit. His part in the world's work has close connection with those social and economic movements that are conditioned on future development; and the only guide we have for the future is the teaching of the past.

If present courses in engineering are to conform to these suggestions, some modifications in the purely technical subjects are requisite. Instruction in these may well be confined more closely to fundamental principles and to the enforcement of them by the concrete examples furnished by the exercises in the laboratory. A multitude of details do not belong in the instruction given to immature students, but to the actual work of the practicing engineer. If inquiry is made of the experienced engineer from whom he got the most help in his college course, he will not mention the teacher whose instruction consisted largely of a category of details of the engineering art, but rather the one who marshaled the leading facts of the subject under general principles, brought out clearly the correlation between them, and enforced them by the work of the laboratory, which had obvious and vital connection with the instruction of the class-room.

My friends, I have seen young men develop into engineers who are now engaged in leading work in the world. They are directing large operations in telephone companies, holding influential posts in electric light and power industries, directing new enterprises destined to develop resources, superintending manufactures of large moment, and supervising construction undertaken by the Reclamation Service of the federal government. Such men as these give me great hope for the future of this institute planted in the most attractive spot in the empire of California south of the Tehachepi. This is a region abounding in undeveloped possibilities. Its water powers, its mines, its reservoirs of liquid fuel, its irrigation possibilities, coupled with a soil in which nature has been lavish in her gifts of productiveness, and its ocean shore in touch with the wealth of the orient, all combine to offer a field to the aspiring engineer unsurpassed in history and written all over with fetching inducements to noblest effort.

The young man who wishes to become a component part of this empire as an engineer will enter this institute and take a straight course, looking for no short cuts to a degree, expecting no magician to lift him over hard work, and later to put him down softly in easy engineering positions. To all such the Throop Polytechnic Institute says, "Come this way!"

ENGINEERING AND LIFE.

By

Professor Frank H. Constant.

Professor Constant, who is still a young man, occupies the chair of Structural Engineering in the University of Minnesota. This address was prepared by him for delivery to his students in 1907. His discourse is sound, thoughtful, and scholarly; and no one who reads it can fail to receive much benefit from the author's lofty ideals.

Professor Constant was born at Cincinnati, Ohio, July 25, 1869, and was graduated at the University of Cincinnati in 1891 with the degree of C. E. From 1891 to 1893 he was in the designing and estimating departments of the King Bridge Company at Cleveland, Ohio. From 1893 to 1895 he was with the Osborn Engineering Company, of the same city, in charge of designing. In 1895 he took the position of Assistant Professor of Structural Engineering in the University of Minnesota, and in 1897 he was made full professor in that department, which position he still holds.

In addition to his teaching, he attends to considerable outside practice; for in 1899 he was Resident Engineer to the Minneapolis and St. Louis Railway Company, and in 1900 he was in charge of the reconstruction of the Northern Pacific Railway Company's bridge over the Mississippi River at Brainerd, Minnesota. From 1905 to 1907 he was Consulting Engineer to the Twin City Rapid Transit Company, in charge of the reinforcement of the Lake Street Bridge across the Mississippi River between Minneapolis and St. Paul, and of the designing of various bridges and viaducts and a tunnel.

He spent his sabbatical year, 1910-1911, in Dresden and Munich.

He is a member of the American Society of Civil Engineers and of the Society for the Promotion of Engineering Education.

Editors.

ENGINEERING AND LIFE.

By

Professor Frank H. Constant.

A man grows in proportion as he touches life, and no man needs this vitalizing touch more than the engineer. The world does not fully understand the engineer nor appreciate the true nobility of his work. It is inclined to regard him as uncompanionable, as unsympathetic with the higher things of life, as one with ideals which are mechanical and practical and therefore low. And, as on the one hand he has felt this lack of a humanizing bond between himself and his fellows in other walks of life, and on the other has tasted the real joy of his work and found there an absorbing interest, he has withdrawn more and more from life in its broad sense, becoming individualistic, unsocial, and out of sympathy with everything not distinctly engineering in its nature. I am speaking now of the general type.

Negatively the engineer has been characterized as a man with the social instincts poorly developed, who is more at home in the field or office than in the drawing room, whose conversation runs to facts and figures rather than to general ideas and speculative truth, whose reading is confined to the almost unlimited field of technical literature with little or no browsing in the fields of letters, art, science, or general knowledge, whose mental processes are concrete and mathematical and bear upon the practical problems with his daily work, finding little time for the vast world of thought outside of his own calling. "I would rather have one good engineering formula than all the logic ever written," was the rather crushing reply from an engineering classmate when the writer, with doubtless much show of egotism, was displaying his newly acquired knowledge of formal logic, in the old college days. The writer remembers the loud laughter which accompanied a bright young Sibley College graduate's description of an academic classmate who was fond of scouring the country waysides with a butterfly net. Is not a general lack of sympathy with branches of knowledge whose utilitarianism is not immediately apparent, a general characteristic of the engineer? With what impatience and lack of interest most engineering students pursue prescribed studies having no immediate bearing upon their technical work. Nay more, even in a strictly technical subject the instructor must emphasize the practical bearing of each part of his instruction. Let him, in his enthusiasm, momentarily wander off by the wayside with

net in hand to catch the whole truth of his subject and he is summarily brought back to the wide and beaten path by the sudden falling off of the interests of his class. How to do things, not why they are so done is the question he must satisfy.

Happily there is another, a positive side in the analysis of the engineer. Generally he is a man of sterling character, of rigid honesty in the midst of manifold temptations, devoted to his work which he finds absorbingly interesting, a hard and usually inadequately paid worker finding compensation in successful achievement, kind but firm to his subordinates, loyal to his superiors, jealous of his reputation, unostentatiously proud of his own and other engineers' achievements. Narrow, if you will, because he is little interested in letters and art, but finding his own chosen field broad enough to occupy all of his time and energy. No more narrow, therefore, than many another faithful worker who finds the business of life all absorbing. But not narrow in the sense that his intellectual development is dwarfed, for it may truthfully be said that the engineer who attains to modicum of success must possess intellectual power and training at least equal to that required for a like degree of success in any other calling. In a word the engineer possesses character, intellectual power, and an intimate acquaintance with Nature's ways and laws. He needs but the humanizing touch with life to round out his character and immensely broaden his sphere of usefulness. How may he more closely touch life and how will it affect his work and personality?

The first care of a sturdy and virile man who wishes his presence in this world to add a little to the sum total of human progress, is for the partial success, at least, of his chosen life work. Now success in an engineering sense at the present day, is not simply graduation from college, a position in an office or field, and a permanent devotion to technical details which gradually narrow in scope as the advancing years bring greater and greater specialization. Such a man may rise to the head of an office, he may design important structures and justly be proud of his achievements, and yet ever wonder that his compensation is no greater. Such is the type of the older generation. The office man was out of place in the field; and both office and field men were accounted impractical in the management of executive affairs. He was not supposed to have broad ideas upon economic policies nor to present what views he did have forcibly and effectively. He was selected not for executive positions but to work up the details of projects which others planned and benefited from. He was regarded as an expert technician, and his success was measured by the skill he possessed in grasping technical details and by his creative power in solving new and

complex engineering problems. That he has risen magnificently to this height, there is no shadow of doubt. That he must be an expert technician before he can go farther is likewise true. But, in addition to this, his life and training should especially fit him to direct large business interests involving details where engineering judgment in a broad sense is the desideratum of success. His special fitness in this regard is beginning to be recognized in very recent years by the business world. Just as fast as engineers have shown executive capacity they have been advanced to such positions, and generally, whenever they have taken hold, the increased efficiency of the management has been marked.

These men have developed the capacity to direct large affairs only as they have learned to understand their fellow men. Like Antaeus whose strength was renewed each time he touched mother earth, the engineer grows by contact with life which is Nature in her highest and most interesting aspect. As these words are addressed mainly to young men about to enter the profession of engineering, whose ideals for future professional success are, or should be very high, a few words of advice may not be out of place. Every piece of engineering work is ultimately performed by men, skilled or unskilled. The young engineer should endeavor from the start to learn as much as possible about these men who actually do the work. It is not enough simply to supervise their work. You cannot find the real man in such superficial contact. The important thing is to learn the workingman's point of view, how he looks at things, his strong points, his frailties, his real capacity, his sympathies and prejudices. Such a knowledge can come only by working side by side with men, rubbing shoulder to shoulder, by being one of them. Instead of seeking a pleasant position upon an engineering staff, the student should spend his vacation in the shop or on the track or in a constructor's crew. He will learn many small details in practical construction which he can get in no other way, he will get the strong body and physical vigor which are so necessary a foundation for the continuous mental strain of after years, but above all he will acquire a real knowledge of the men whom later on he must direct, organize, and use efficiently. Likewise, young graduates should seek the shops and field crews for their early experience. The chief engineer of a large railway system when he graduated from college, accepted an engineering position where he had to pass upon the work done by construction crews. After several years he realized that he did not really understand the work nor the men whom he had to direct. He went to a place where he was unknown and joined a railway carpentry crew; later went into a blacksmith shop; then into a foundry; finally into the mines; always starting as a novice and remaining long enough to be-

come a master workman, foreman, or superintendent. After four years of this kind of life he went back to his engineering work and advanced almost immediately into a high executive position; and the knowledge of men which he gained by this experience makes him one of the leading engineers in the country. Perhaps all men will not respond equally well to this kind of experience. Many will lose sight of the end in the humble routine of elemental life, and tiring of the drudgery turn to something easier and pleasanter. Some may be harmed by the rough life. But it may be asserted that in neither case do these men have the strength of character necessary for success in the highest sense. They would have fallen by the wayside in any event. I am speaking for the men who can really succeed in engineering, who have the ambition, the character, the industry, the staying powers, the mental force. These men cannot but be helped by beginning at the bottom.

Salary and even comfort should be no consideration during the first two or three years. Call it a post graduate course if you will: what one is after is contact with men and life, full, abundant, complete. Will his ultimate advancement be delayed thereby? Probably not. In some cases it may even be hastened. Will he have forgotten much that he learned in college? Possibly. He went to college for the mental training and that still abides with him. But he has gained a new and more vital knowledge—that of life itself—which cannot be acquired from books nor in the classroom. Moreover, if he is the right kind of a man, he will not be scholastically idle during these elemental years. He will seek relief from the rough toil of the day in his books and studies. He will not be stagnating mentally, but will be growing at the roots with amazing rapidity and virility. During this period, while he has been studying the real self of the men who work, he will also learn much about the men who command. As he quickly climbs from the lowest round of the ladder into higher and higher positions, his interest in men will broaden and become universal. Such a man, if placed in high executive positions, will know how to meet and to move men and will understand the capacities of the men under him. Thus a constant and close touch with life is essential for his highest professional good.

Thus far we have considered success from the standpoint of professional advancement. But as man is more than vocation, so his real success in life is not to be measured wholly in terms of vocational achievement. It is in this lack of a broad appreciation of the real meaning of success that the engineer makes his greatest mistake, leading, as we have seen, to the narrow type of our early characterization. Whatever broadens the whole man must necessarily better fit him for his special work. The engineer, wrapped in his individualism, imagines

himself different from other men and therefore freed from their common obligations. This point of view is fallacious. Many a good physician or lawyer or minister might have become a good engineer if he had started that way, and vice versa. Doubtless the average engineer has a natural mechanical bent drawing him to mathematical and mechanical problems; and in some few men this bent is so strong that they may be unsuccessful in any other calling. But few men are so decidedly called to a particular work, and in most cases the final choice is a matter of great conflict of mind. Success in engineering, as in any calling, depends upon hard application and experience. The instinct to construct is native-born in most men, clearly manifested in early childhood. It is certain that the engineer is made from quite universal stuff, his growth depending upon such common elements as intellect, mental training, industry, perseverance, experience. He is above all a man, and our final perspective must consider him from this view point, in which his work as an engineer must take its relative place with all the other activities of his life. It is but a part of the whole, in which all the parts are sympathetically related and all working together for the common end—the full development of the man. We cannot therefore get this largest and truest perspective of the engineer unless we also consider him from the standpoint of his common manhood and its relation to other activities of life. He cannot develop in the highest sense as an engineer unless he likewise grows as a man.

Men are broadly classified in the two-fold way as political and social units. As a political unit the American engineer finds himself a member of a democracy. But democracy means that a grave responsibility rests upon each individual, in proportion to his capacity, to take a real part in the government of his country. President Roosevelt said in a recent address at Harvard: "I want you to feel that it is not merely your right to take part in politics, not merely your duty to the state, but that it is demanded by your own self-respect, unless you are content to acknowledge that you are unfit to govern yourself and have to submit to the rule of somebody else as master—and this is what it means if you do not do your own part in government."

The many grave problems confronting the republic will be wisely solved only when every citizen considers himself personally responsible for them and applies as much thought to their solution as he does to his private business. The responsibility of citizenship falls heavily upon the engineer, for not only is he especially fitted by his training to handle large problems, but many of the public questions involve broad engineering principles, and too often he is the most listless of citizens.

If the engineer will not interest himself in these problems, can he expect others to be more faithful or to find better solutions?

As a nation we are notoriously selfish in the pursuit of our own private ends, indifferent to its best welfare except when our own interests are threatened. thankful if the ship of state will but keep off of the rocks. As a democracy we have fallen far short of the ideal simply because the educated and broad sighted men of the country have not given their efforts in its behalf. The building of a bridge or railroad is undoubtedly for the public weal. But more important still is the building of the ideal democracy in which all men will truly share in its government and all problems will be solved in the spirit of unselfishness and with wisdom. Here is to be found the meaning of true patriotism—a patriotism which, day by day, in the midst of more selfish interests finds the time to work for the country's best welfare.

The engineer is likewise a member of society, from which he gets much and to which he owes much. Society is the relation of man to man. He gets from it not only the knowledge of life as it exists at present, but the history of its past development as it has left its impress in art, literature, science, and human experience. It alone has made possible the evolution of man from a lower to a higher state. In its rich soil alone the individual soul may germinate and expand into something larger and nobler. Man, and especially the engineer, cannot afford to withdraw from its stimulating influence.

We have seen how breadth of view is essential to the highest success of the engineer. So also is a broad liberal culture necessary to the development of the whole man. Truth is not confined to any one branch of human knowledge. She is like the many colored woof of cloth tracing its way in and out over the whole field. He who would know her as she truly is must seek her in many habitations. No man can compass the whole of human knowledge, but he can keep himself atune with it, ready to vibrate on all sides. I would counsel the young engineer, fixing his ideal at nothing less than the fullest development of the whole man, to let a love for knowledge—for truth as seen from many sides—spring up and grow alongside of his enthusiasm for engineering. Especially should he seek the so-called humanities, which teach of man's relation to man, for here he will find the mainspring of human action. Students of engineering should not avoid but welcome occasional subjects chosen from this group. I hope the day will come when our engineering colleges will require one or two years of academic training for entrance to the technical courses and that even these will be as broad as practicable.

A broad culture fits a man for any society. But if the end were simply selfish—his own increased enjoyment of life, or greater professional advancement—it might not be worth the seeking. But each man should pay back to society something that he takes from it, and his present duty is clear. In spite of ever increasing wealth and prosperity, in spite of great achievements in science and particularly engineering science, bringing increased comfort or luxury to every man, the ideals of society as a whole are disappointingly low. Power and wealth are sought for their own sakes; commercialism and rapid living rule the day. Nearly every one is caught in the tide and, in spite of better judgment, swept along with the current. It is the man of broad culture and high ideals who must lead the way to things better worth while, that the lives of the majority of men may not be wasted seeking baubles. Man may not live by bread alone. The engineer, especially, has been accused of materialistic ideals, and as one whose life is spent in a mechanical atmosphere and who often controls the spending of large sums, he is prone to over-rate the real value of these things in life. He, too, needs the broad culture that leads to a sane perspective of life and its high ends.

Our engineering colleges draw many recruits from humble homes in which the stern conditions of life have left no place for culture. To most of these young men the engineering college is the door to a position, work that is stimulating and interesting, a comfortable living. To many this preachment may seem too idealistic and therefore impracticable. They are thankful to get a good position and to enjoy an increasing salary. They become valuable to their employers, their living is assured, they are happy. Culture (they think) is not a concomitant of engineering; and having started with little, why bother about it at all? The man of narrow view does not understand breadth of view; the man in the valley has no conception of what the man on the hill top is seeing. It is the men at the top and not those at the bottom (however numerous), who stamp the true character of a calling. The uncultured engineer, finding himself in a numerous crowd, may think that his view includes the whole length and breadth of engineering, and that, like a fraternal order, having once been admitted to membership he has been initiated into all its secrets and henceforth may enjoy an equal fellowship. The outside world seeing the large membership of the uncultured imagines that this is the type that all engineers must conform to—that it is essentially a narrow and unidealistic calling.

Of course this opinion is incorrect. Engineering is not a fraternal order, but a progressive vocation with a definite bottom and offering unlimited opportunities for expansion upwards. Many have reached high eminences and have enjoyed the society and friendship of the

greatest men of their time. The names of great engineers have come down to us from all ages along with those of statesmen and generals. In Westminster Abbey there is a memorial tablet to Robert Stephenson, the great English bridge engineer, whilst in the crypt of the cathedral of Glasgow a similar memorial to the same man is the shrine visited by thousands. England honors many of its great engineers with knighthood. In Europe the engineering profession is regarded with honor and of equal rank with the other learned professions, but in these countries entrance into this, as into any of the professions, requires long years of very rigorous training superimposed upon a broad foundation of general culture.

But it is not necessary to turn to Europe to find the true place of engineers in the society of men. This country has a long roll of honor which contains names that any profession or any country might well be proud of; men who are not only great engineers, but gentlemen of the highest and broadest culture. The young engineer should turn his eyes upward to see what engineering truly is, and from the illustrious men at the top catch the inspiration and ideal for his professional life. He will find these men truly broad both as engineers and as men, and he will find further that it is because of their breadth that they are great engineers.

Engineering is a noble calling and the men who follow it need not necessarily, if they so mind, be swallowed up in a sea of materialism. Matter is universal and clothes the seat of thought and spirit. In molding matter to the uses of man the engineer but adapts himself to the conditions of a material world. The real engineer is the intellectual force and spirit back of matter. So far from being debased, he is to be congratulated that his mind may work in such close harmony with nature. His mental processes are sane and true, and drawing their inspiration from nature they find there an unlimited source. He need not be ashamed of his calling; let him see to it that he is worthy of it and that he use the rich opportunity to grow into the full measure of manhood.

LIMITATIONS OF EFFICIENCY IN ENGINEERING EDUCATION.

By

Dr. George Fillmore Swain.

Although this address was not prepared directly for the benefit of engineering students, but more especially for their instructors, it contains, nevertheless, many matters of interest and value to undergraduates, which alone would be sufficient reason for its reproduction here, even if it were not the sole specimen given of Dr. Swain's writing. Without an example of his diction, the book would be incomplete; because he is one of the most noted engineering instructors of America. For many years he taught civil engineering at the Massachusetts Institute of Technology, at the same time attending to a large private practice, including membership on important engineering commissions of his State; but lately he has been called to Harvard University to take charge of its post-graduate course in engineering.

No comment is necessary concerning Dr. Swain's lecture, the high character of his ideas and the forcefulness of his expression being evident to the most casual reader.

Dr. Swain's professional record is as follows:

Graduated in Civil Engineering in 1877 at Massachusetts Institute of Technology with the degree of S. B.

Studied from 1877 to 1880 in the Polytechnic School at Berlin under Professors Winkler, Hogen, and Goering.

From 1880 till 1883, Expert on water power for the U. S. Government, spending the summers in the offices of Locks and Canals at Lowell and with the Essex Company in Lawrence.

In 1881, Instructor in Civil Engineering at the Massachusetts Institute of Technology; and in 1883 Assistant Professor in Civil Engineering there. From 1887 till 1909 he was Professor of Civil Engineering in charge of the Department at the same institution.

In 1906 he received the honorary degree of LL. D. from New York University.

From 1909 to date, Cordon McKay Professor of Civil Engineering in the Graduate School of Applied Science at Harvard University.

From 1887 to date Consulting Engineer to the Massachusetts Rail-

way Commissioners, particularly with reference to railway and highway bridges.

From 1894 to date, Member of the Boston Transit Commission, which has expended up to the present time nearly twenty millions of dollars.

Since 1910, Expert for the Commission on the Validation of the Assets and Liabilities of the New York, New Haven, and Hartford Railroad Company.

In addition to the preceding, Dr. Swain has done a great deal of other important work as consulting engineer, including valuations of many railroad properties; and he has served on several commissions in various states of the Union.

He is a member of the leading technical societies of America, England, and Germany; and has been President of the Boston Society of Civil Engineers and of the Society for the Promotion of Engineering Education—also Vice President of the American Society of Civil Engineers.

Editors.

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By

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Our colleges, universities, and technical schools are at the present time the subject of serious criticism at the hands of many writers, some of them in high authority in educational matters, some of them outsiders with no teaching experience, who judge of the work of the schools by the men that are turned out. Even the presidents of some of our educational institutions, if they have been correctly reported, admit that much of the development of the last few decades has been, if not in the wrong direction, at least incomplete or unsymmetrical, and that important modifications need to be made in regard to methods of instruction and administration, as well as in matters of general educational policy. Critics outside the teaching profession, joining in the complaint, have pointed out what they consider serious faults, and have indicated how, in their opinion, our colleges should be reorganized.

While most of this criticism has been directed against the colleges, the engineering schools have come in for their share. Engineers of eminence, like Mr. F. W. Taylor, and employers of engineers, like Mr. Crane, have told us that the engineering graduate, when he leaves the technical school or the university, is of little or no use to his employers—at least until he has been seasoned by several years of experience in contact with the hard world—with the solid facts of life.

Let me invite your attention for a few moments to a consideration of the questions what the engineering graduate might be and ought to be when he leaves the school, what he too often is, and what some of the difficulties are which prevent the attainment of the ideal; in other words, let us consider some of the limitations of efficiency in engineering education.

Let me first admit that a long experience in teaching has convinced me that there is much truth in the criticisms which have been made. I fully believe, however, that they have been often exaggerated, and, moreover, that many of the defects that have been pointed out are capable of remedy.

When our technical schools were new, say forty or fifty years ago, the value of a scientific training was not appreciated by manufacturers,

or even by members of the engineering profession itself. The majority of engineers had not had the advantages of a thorough education, and indeed, it had not been fully realized that engineering was a science. It was considered a branch of the building art, and its practice was largely empirical. Consequently, engineering graduates often had difficulty in obtaining positions, and their scientific acquirements were considered to be of little use; the young graduates were looked upon as theorists, and as inferior to the practical men who had gained their knowledge by experience. A sharp contrast was drawn between theory and practice, as though the two were incompatible; and the practical man, whether engineer or employer, scoffed at the theorist, often only too justly.

All this, however, rapidly changed; the schools soon realized the fact that they could not make a man an engineer, and that they should confine their attention mainly to giving him the foundation of scientific principles on which he could build, and which would enable him, as he should gain experience, to understand and coördinate what he had learned, and thus to practice his profession in a truly scientific way. The teaching of engineering instead of being done by mathematicians, or men with no practical experience in the things they were teaching, began to come into the hands of men who were practical engineers as well as scientists, and who knew the importance of teaching mathematics and mechanics in such a way that they could be used as tools instead of regarded as abstractions.

Employers engaged in business in which the applied scientist could legitimately be useful, on the other hand, soon learned that many of these young men could do things which were entirely beyond the power of the unschooled man, even with years of experience. Visiting one of our engineering schools some twenty years ago for the first time, one of these employers was quite surprised at what he saw, and at the work which had been done by the students. Upon leaving the president of the institution, he said that he had been much impressed, and thought he would take a number of men of the senior class as soon as they were graduated, to which the president replied that he would not take these men, because they all had been already spoken for.

This change is still going on. The enormous development of engineering, and the growing recognition of the fact that a university or college, instead of giving a man so-called culture only, should train him definitely for active work in the world, led to the corresponding development of engineering departments. And, certainly, of the work of the world, a very large part is dependent upon applied science, and the engineering department of a university should be one of its strong-

est and largest departments. Teaching which is concrete and practical, yet thoroughly scientific, is increasing, and graduates more and more capable of immediate usefulness, and at the same time better trained, are being turned out year after year.

Mr. Taylor sweepingly declares that the manufacturers of this country do not want anything to do with young men just coming from technical schools,—that they would rather not have them, and find them of little use in their business. This, I think, is a great exaggeration. Mr. Taylor has had a long experience, and an opportunity to come in contact with large numbers of manufacturers; nevertheless, I doubt the accuracy of this statement that the graduate is not wanted. Certainly it is not true, according to my experience, in the case of graduates in civil engineering. The railroad companies of this country, who are perhaps the largest employers of engineering graduates, desire all they can get, and some of them make it a rule to recruit their forces, if possible, entirely with such men. Our structural companies prefer them—in fact, desire no others if they can get technical graduates personally recommended by their teachers. In hydraulic engineering, sanitary engineering, and all other branches of the civil engineering profession, if we are to judge by the demand for these men, they prove themselves immediately serviceable, and in the vast majority of cases they advance rapidly enough to demonstrate the fact that their technical education has been of great advantage to them.

A similar condition seems to exist with reference to mining and electrical engineering. I am told that your great electrical company recruits its engineering staff, if possible, entirely with technical graduates. As for mechanical engineering, I am sure that the demand for such graduates from at least some of our schools is far above the supply. If, as Mr. Taylor affirms, the manufacturers of the country do not find these men useful, I for one am sorry for the manufacturers. I regret that they are so far behind the procession. If the statement is true, perhaps that is the reason why those manufacturers consider that they need so much protection against the competition of foreign countries, like France and Germany, where the technically trained man is unquestionably fully appreciated, and where technical schools have been longest established.

President Draper finely expresses the value of a higher education when he says: "With an independent, sane, balanced character, having the elements of success anyway, the advantage of a college training cannot be over-estimated." This is even more true with reference to a professional education.

The young man from a technical school should have passed through four years of discipline—mental, moral, and physical.

His physical discipline should have enabled him to restrain his appetites, to govern his passions, to make his hand and eye quickly responsive to his will, to be a master of himself. His step should be firm, his carriage erect, his muscles hard, his body capable of enduring much physical fatigue.

His moral education should have made him realize the ethical principles which should govern a man's acts in this world and regulate his conduct toward his fellow men. He should have learned to be truthful and honest; thoughtful and forgiving toward others; stern and unforgiving toward himself. He should have learned the supreme lesson of disinterestedness, and should have gained the power of working for the sake of the work and its results rather than for his own selfish purposes; he should have learned to look down with something like contempt upon the petty things of this world and to realize that they amount to little compared with the perfecting of his own character.

His mental training should have enabled him to estimate justly his own powers and to know how to use them. He should have had an opportunity to "find himself" and to study his own tendencies and innate talents; and he should, therefore, be in a position to direct himself toward the field of human endeavor in which those qualities will enable him to do the best work. He should have learned thoroughly the fundamental principles upon which are based the branch of engineering which he is to follow, and the power to apply them intelligently and correctly. He should be modest, realizing how little he knows and how little experience he possesses, yet self-reliant, feeling that he has mastered the fundamental principles which he is to apply in the world of action. He should be possessed of mental courage, having been taught to study a subject with no preconceived ideas or prejudices, but solely intent on reaching the truth. He should be able to observe accurately, and to reason logically from premises gained by observation or otherwise.

The average engineering graduate, and especially the college graduate, unfortunately falls far short of this ideal, although it is measurably within the reach of all. The causes of his failure are partly due to the student himself, partly to his parents, partly to the college.

Let me call your attention to some of his shortcomings, the reasons for them, and the possible remedies for them, as they appear to me.

Physical Training.

In the first place we are too apt to understand by the term "education" simply mental education; moral and physical education or train-

ing do not receive the proper degree of attention. In some of our colleges and technical schools no effort whatever is made to give physical training, to develop a sound physique, to discover and point out physical defects, and to apply some systematic corrective. Athletics, as at present cultivated, affect only the few men who, voluntarily or by solicitation, engage in them. The great mass of students takes no part in them, except to look on and applaud when the home team wins. In my opinion, every college and technical school should insist on some physical training for every one of its students who is not physically incapable of it. A man may, by reason of some hereditary weakness, or accident, be obliged forever to renounce the hope of being physically strong. That is his misfortune, and it may exclude him from the possibility of practicing certain branches of the profession; but if he has the other qualities which lead to success, he need have no misgivings. In such case, he should, by cultivating temperance in all things, and by careful observance of the rules of personal hygiene, preserve to himself all the physical vigor possible. The man who is physically most robust may not last the longest, or do the best work in the world. Success depends, not upon one quality, but upon the proper combination, and physical strength is perhaps the quality which may be most easily dispensed with. Probably this is the reason why it has been neglected.

Nevertheless, physical training should be insisted upon. It should be preceded by a thorough examination of each man, by an expert who should prescribe what exercises will best strengthen the weak spots and develop the physical endurance which is likely to be such a valuable asset to an engineer. Every student would also gain much were he required to take a course in physiology, so that he may be made acquainted with the laws of personal hygiene, and know how to take care of himself and to regulate his diet. Physical training is perhaps of more importance to the engineer than to members of any other profession, for the engineer is essentially an out-of-door man, or is likely to be one, and his capacity to endure fatigue and hardship if called upon, may be an essential element in his success. It is hoped that such a course would lead the student to abstain from all but the most sparing use of tobacco and alcoholic beverages. He will be fortunate if it leads him to renounce them entirely.

Moral Education.

In the second place, moral education is, as a rule, much neglected. By many teachers or even institutions it appears to be considered that this should be left entirely to the home and the church—that the school should simply train the mind. This seems to me a fundamental mis-

take. It is sometimes said that the salvation of a democratic country like this lies in a widely diffused and high standard of education. It would seem clear, however, that the kind of education upon which our salvation will depend is moral education rather than mental education. Half knowledge is, proverbially, a dangerous thing; and a smattering of economics, history, language, science, or what not, such as most students acquire, or even a thorough knowledge of them will not enable a man to perform properly the duties of a citizen, if he has failed to become imbued with the moral law, and to realize the supreme importance of his duties toward his neighbor, and the necessity of playing the game of life fairly. Dishonesty is not confined to the poor or the ignorant; it is doubtful if it is more frequent among them, on the whole, than among the educated and the well-to-do, notwithstanding the many and varied temptations which poverty necessarily brings.

Not only, therefore, should the college or technical school require some training in subjects which will imbue students with an appreciation of the importance of the moral law, from the professional as well as from the personal point of view, but every teacher should consider himself, so far as consistent, a moral teacher and should seize the opportunities, which will often come, to enforce a moral lesson.

Mental Education.

But coming to what is generally considered as education, that is, mental education, most graduates of our colleges and technical schools are no doubt far removed from the ideal which has been sketched. Not only have many of them failed to master thoroughly the fundamental principles which they are supposed to have learned, but they are not able to observe correctly or to reason logically; and they have, furthermore, so little realization of their own defects and are possessed of so little modesty, that they go out into the world with an overweening and unjustified conceit, with an unwillingness to begin at the bottom and learn a business thoroughly, and with an inability to do cheerfully, uncomplainingly, persistently, and enthusiastically, the routine work or drudgery of which the greater part of the world's work consists, and in the proper doing of which the highest discipline lies. They are uneasy if they do not quickly receive promotion; they are impatient of the self-taught, unschooled men who work by their sides, although these men may be their superiors, and possessed of far more common sense than they; and because they have wasted a great part of the time which has been devoted to their education—perhaps some of it in riotous living—they are unable to appreciate the things which the untaught man may have learned and which they have still to discover.

Measuring Efficiency.

The engineer, in estimating the performance of a machine, measures its value by what is termed its "mechanical efficiency." This is the ratio of the effective work done by the machine to the energy which is put into it. The higher the efficiency the better the machine. The efficiency of a business may be measured somewhat in the same manner; in this case best, perhaps, by the ratio of net earnings to the total investment, provided that the investment has been properly expended. Of course, one business cannot in this way be compared directly with another on the same basis, for in one sort of business the possible net earnings may be far smaller compared with the total investment than is the case in another kind of business. Nevertheless, there is a sort of measure, even if rough compared with the mechanical one. That measure is expressed in dollars. Since dollars are desirable or necessary to those who have invested in the concern, if a low efficiency is shown—lower than should reasonably be expected, or lower than is shown in similar concerns similarly situated—there will probably be a demand for a change of management.

I have often asked myself the question: What is the efficiency of education? Unfortunately, however, there is no measure for that efficiency. The manufacturer takes the raw material out of which he manufactures his produce—a log of wood, for example;—he pays for this raw material and for the labor expended upon it, in money; fashions it into the form desired, and sells it for other money. The efficiency of the entire process can be measured, if not with exactness, at least approximately.

In education the raw material is the student. Labor, enthusiasm, and money are expended upon him. The product is the improvement which results to him mentally, morally, and physically, and this is incapable of quantitative estimation. Nevertheless, I have for a long time believed that if it could be estimated it would be found that the efficiency of education is in general very small; that the result in improved physical strength, morality, power of thought, is but a small fraction of the energy expended.

But even if the efficiency is small, it does not follow that the work is not worth doing, or not done well. The light given out by the electric light represents less than 1 per cent of the theoretical energy in the coal, yet it does not follow that electrical lighting is not worth while. It depends upon the intrinsic value of the product. So, in education, to inspire and discipline even a few young men may be worth far more than all the effort expended upon them and others, for it means keeping alive the torch of learning, and feeding the flame of research, so that the

treasures of thought and the methods of scientific investigation may be transmitted to those who shall follow us, and so stimulate intellectual progress in the years to come.

It is also essential, before judging of the real value of higher education, to estimate the necessary limitations of efficiency, to consider the inevitable losses and sources of waste, and thus to refer the final product, not to a purely theoretical and impossible maximum, but to a practically attainable one; in other words, to consider the reasons for the observed defects, and to ascertain to what extent they are practically remediable.

These defects seem to arise from four main sources: 1, the student; 2, the parent; 3, the teacher; 4, the adminstration.

The Defects Due to the Student.

The main source of the inefficiency of education and the principal justification for the criticisms which have been made upon its results, seem to me to lie in the students themselves. They go to the college or technical school, where they find afforded them abundant opportunities; but many of them are lacking in will, and are not able to avail themselves of them.

While the manufacturer, by the application of external power, molds his raw material into the desired form, education cannot so fashion its raw material. The fundamental difficulty with education seems to me to be the fact that the only culture or training which does a man any good is *self-cülture,*—that which he imposes upon himself. The teacher may present his subject with perfect clearness, he may give examples to illustrate it, he may impress upon his students emphatically the necessity of doing certain things, he may tell them what to do, and what not to do, what mental and moral habits they must cultivate and which they must shun, but he cannot make them follow his injunctions. Many of them will be found to lack the interest and the will to see the necessity for self-exertion, and to impose upon themselves the moral and mental discipline without which success in their work will not be attained.

This may not be due to any lack of good intention; they may be earnest enough, they may work long hours, but many of them will not work in the right way, no matter how often they are shown, nor will they take the trouble to learn the methods of logical thinking. They are lacking in will. They do not realize that their success will depend more upon their wills than upon their brains.

Dr. W. H. Thomson, in his most interesting book, "Brain and Personality," says "we can make our own brains, so far as special mental functions or aptitudes are concerned, if only we have wills strong

enough to take the trouble." When to this is added that the will, like any other function of the human being, can be trained, and its strength increased, we have the *fundamental* principles of self-culture, which do not begin to be appreciated as yet, either by students or by teachers.

If the attempt is made to force the student into a rigid system to control his every movement, he may be to some extent disciplined, but his interest, his initiative, his spontaneity, and his power of self-control, will not be developed. It is the old question whether a young man can be trained to self-control by keeping him in subjection,—whether he can be trained to govern himself except by letting him try—which seems to have been decided, and, on the whole, wisely decided, in the negative.

A certain amount of military training, for instance, is no doubt of advantage to every one; it develops obedience, promptness, and other similar qualities; but it does not train the will, nor teach self-command, nor stimulate the highest faculties. Soldiers are not noted for self-control as compared with those who have not been exposed to military discipline. Indeed, the moment the usual pressure is relaxed they are only too apt to show the absence of that quality; nor have many advances in learning or in the arts come from military men. At some time in a young man's life, he must be thrown upon his own responsibilities, and it would scarcely seem wise to defer that point until the end of the college course. If he is not ready to learn that lesson in college by the time he is 17 or 18 years old, there is a strong probability that he ought not to be sent to college at all, but that he should be made to learn the lesson, if possible, in the harder school of the outside world; and let such a man be thankful if it prove a school of hard knocks.

Right here it may be remarked that much of the criticism of our schools would not be made if it were recognized that the trouble is not alone what they do or what leave undone, but that the right boys are not always sent to college. There are multitudes of young men there who never ought to have been sent—who are not qualified to take advantage of the kind of training which the college really ought to give, and which is the very best kind for those who can avail themselves of it; whose will and whose natural ability will not justify a higher education; one thousand dollar men who are being given a five thousand dollar education. And there are also multitudes of young men who would take advantage of such opportunities, who cannot afford to do so.

One of the most hopeful signs in our educational progress, to my mind, is the increasing opportunity for deserving young men to get all the education which they are good for, provided it does not give them more than they are good for.

Our schools, from the bottom up, should be better designed to prepare men for their proper vocations in life—industrial, farming, or professional—to guide each man better into his proper field, and to prevent him from entering into fields for which he is not suited. It is far better to be a good mechanic than a poor engineer or lawyer, and there are just as many opportunities for a good mechanic to be advanced to responsible administrative positions as for the poor engineer. One of the main problems of education would seem to be to guide each man into his proper place so far as possible.

No better proof of what has been said is needed than the fact that so many men who have attained success despite the lack of educational advantages, send their own sons to college, realizing how much they themselves might have gained from such an opportunity. Unfortunately, too many such parents fail to realize how much of their own success has been due to the fact that they were obliged to overcome difficulties; they do not train their sons to do the same; they give them too much money to spend, and thus they send them to college unprepared to utilize the advantages presented.

We talk much of opportunity. We do not sufficiently realize that necessity is, on the whole, a greater element in success, and a better friend, than opportunity.

There are many other difficulties which arise with the student, but I need not dwell upon them. Many students are "sent" to college; they do not go, they are sent. They take little interest in their work; their main object is to get through. When they study a subject, their minds are fixed upon the mark which they are to receive, on the examination which they are to pass. Instead of being disinterestedly concerned with getting the most they can out of the opportunity which the course presents, they will procure old examination papers and a tutor, and get themselves coached so that they may be able to scrape through, after which they will promptly dismiss the subject from their minds. A long experience in teaching has convinced me that no amount of effort by the teacher will have much effect in the case of some students in inducing them to take a different attitude.

The fundamental difficulty, then, with the student, is that discipline and correct thinking are not things which can be imposed upon him from without, but things which he must acquire for himself and which he can only learn to acquire for himself by being given the opportunity. To use a favorite illustration, the school is not a restaurant where a man goes to be filled up, but it is a gymnasium where he finds the apparatus which, if used as he is shown, will develop him as he ought to be developed.

The Defects Due to the Parents.

Right here is where the parent must bear some share of the responsibility for the lack of efficiency of education. Time will not permit of an elaboration of this branch of the subject. It will suffice to say that the utmost efforts of the teacher will be of little avail unless with the cordial co-operation and support of the home influences.

Mental discipline at college cannot win against social and financial dissipation at home, and all the efforts of the teacher to enforce the importance of self-culture and training of the will will come to naught if the parents think, as many do, that the son is sent to school to buy an education as he buys a suit of clothes. To a parent who was finding fault with a teacher for the slow progress of his son, the teacher replied that he could not put brains and will into the boy as well as instruction.

One great difficulty with the student of engineering arises from his lack of knowledge of the practical applications of the subjects which he is studying, and further, from the failure to realize the necessity for a higher education and the fact that there are many men in what might be called the lower ranks of life who are just as bright as he is. If the student from a wealthy family could be made to realize that the son of the blacksmith around the corner has just as good a brain as he, it would not only make him more democratic and a better citizen, with more respect for the opinions of others, but it would also make him realize that if he wishes to win a high place in engineering, it will be necessary for him to get something which the blacksmith's son does not have and cannot easily get. Experience would be open to both of them, but education might be open to only one.

The necessity of earning his living, the realization that there are plenty of young men in overalls, with as good native ability as he, are two powerful incentives which will make a young man appreciate the value of an education. In order to develop this appreciation, students of engineering should gain some practice in the workshop or in the field; and they should make it a rule if possible from the time they enter the college—or better, from the time they enter the high school—to spend their vacations in some occupation in which they will be earning their own way.

Defects in the Instruction.

But while the main difficulty, in my opinion, lies with the student himself, and with his parents, there is undoubtedly, in most cases, just room for criticism of the teaching in our schools. Among the defects commonly found, a few may be mentioned:

1. There is too great prevalence of courses which are information courses only, and a lack of realization on the part of the teacher that his main object should be to teach the student to think. We may well reflect upon Locke's statement that the objects of education in their relative rank are as follows:

1. Virtue.
2. Wisdom.
3. Good breeding.
4. Learning.

Learning—to which we almost confine our attention—placed last. And even with reference to learning, we often misplace the emphasis. The student must of course be taught many facts, but the main emphasis should be laid upon the use which is made of those facts. Logical thinking is the main object. If the student gains this, he can reason upon new facts and in any subject: if he does not, he simply uses in a rule-of-thumb way the few specific facts which he has learned.

2. There seems to me to be an undue use of the lecture system. This is a very serious evil, in my opinion, and unfortunately seems to be increasing and to be extending even into the secondary schools. A young man may be interested and may gain some information by listening to a lecture, but he will not gain much mental training. The use of lectures without text books seems particularly futile, except, perhaps, in some special subjects. The student should have a text book which he is required to study. The exercises in the class room should consist in finding out whether he has studied it and mastered it, and if not, why not; and a certain portion of time should be taken in enlarging and explaining the subject itself.

A quiz or a recitation enables the teacher to discover the mental defects of his pupils and to point them out. Such a process is indeed sometimes discouraging to the student. He would prefer to remain in blissful ignorance of his defects, and to go through his courses believing that he understands them and is able to think; but a knowledge of one's defects is the beginning of wisdom. We all, of course, have defects, but we never remedy them unless we realize that we have them and what they are. The student, if he takes the proper attitude of mind, should realize that one of the main things that he goes to college for is to have his defects pointed out to him, and he should not thereby be discouraged, but should have the will to impose upon himself a discipline which will correct them.

Grote, in his history of Greece, makes the following statement with reference to the teaching of Socrates:

"The Socratic dialectics, clearing away from the mind its fancied knowledge and laying bare the real ignorance, produced an immediate effect like the touch of the torpedo. The newly created consciousness of ignorance was alike unexpected, painful, and humilating—a season of doubt and discomfort, yet combined with an internal working and yearning after truth, never before experienced. Such intellectual quickening, which could never commence until the mind had been disabused of its original illusion of false knowledge, was considered by Socrates not merely as the index and precursor, but as the indispensable condition of future progress."

Can we improve upon this principle today? Do we sufficiently appreciate and use it?

Until the lecture system is largely done away with, or reduced to an absolute minimum, many elaborate courses will continue to be accompanied with little result. Of course there is a difference between subjects; some require experimental demonstration, and in them lectures may properly form a considerable portion of the course, while others should be conducted almost entirely with the use of the text book and the recitation. The point is, that except for thoroughly disciplined students, who already know how to think and how to govern themselves, lectures should, in my opinion, be reduced in each case to the minimum.

3. Another fault, which seems very common, is that no attention is paid in many institutions to teaching the student *how to study.* Young men animated with the best intentions, work *hard* but *ineffectively* in the endeavor to master the subjects presented to them. It is not sufficiently realized that *hard* work is not what is needed, and will never bring a man success unless it is also *effective* work. A man should train himself to work like a well oiled machine, accomplishing a result easily, quickly, and without friction. Some instruction with reference to the proper methods of study would seem to be essential, yet I have rarely known of such instruction being given.

4. Equally striking is the fact that in many institutions no attempt is made to teach methods of reasoning in general, except in so far as it is done in connection with the special courses. In the Middle Ages logic occupied an important part in higher training, and it was generally taught in universities up to within a few decades. Since that time it seems to have largely disappeared, and in some of our higher schools little or no attempt is now made, except, as already stated, in connection with individual courses, to teach the student the general rules of correct reasoning, in other words, the principles of logic.

It is true that the study of formal logic was carried entirely too far, applied to improper purposes, and, in a word, entirely misapplied

and exaggerated. It would be absurd to revive in their old form the dialectics of the schoolmen. But that is no reason why logic should be neglected; and while the capable instructor may teach much logic in a course not sufficiently devoted to that subject, the fact remains that many, if not most, of the graduates of our technical schools are not capable of independent logical reasoning, even on scientific subjects.

It is, I think, not sufficiently recognized, even by teachers, that there are certain methods of logical thinking, certain fallacies which must be guarded against, certain modes of detecting these fallacies, and certain tests of correct results. Most students seem to think that reasoning is a natural function of the mind just as walking is of the legs; but even if it be true that "the brain secretes thought as the liver secretes bile" it certainly is not true that it naturally secretes *logical* thought. Though a man have a mind, it does not follow that he can think correctly. He must have the logical principles upon which correct thinking depends, and there are many reasons for believing that he will learn them best by consciously studying the subject of logic rather than by taking it as the by-product of other courses.

Locke, in the preface of his most valuable little book on "The Conduct of the Understanding," makes the following remark:

"I cannot think any parent or instructor justified in neglecting to put this little treatise in the hands of a boy about the time when the reasoning faculties become developed. It will give him a sober and serious, not flippant or self-conceited, independency of thinking; and, while it teaches how to distrust ourselves and to watch those prejudices which necessarily grow up from one cause or another, will inspire a reasonable confidence in what he has well considered, by taking off a little of that deference to authority which is the more to be regretted in its excess that, like its cousin-german, party-spirit, it is frequently united to loyalty of heart and the generous enthusiasm of youth."

I have talked with many students from many universities, technical schools, and preparatory schools, and the replies received from most of them indicate that during their whole preparatory and college course they have never been given any instruction corresponding to that contained in this book. The result is that fallacies which any mind trained in logic would be able to observe, pass the minds of these men without discovery.

I am aware of the fact that courses in logic are offered in many of our universities, and taken by a considerable number of students in the aggregate, but I am also aware of the fact that in many institutions, and particularly in technical schools, no such courses whatever are offered; and furthermore, I do not know of a single institution in

which such a course is required. I am further aware of the fact that no amount of instruction would ever result in making some men think logically.

I make a plea for the restoration of logic in some specific form as a required subject in the curriculum of every higher institution of learning.

The study of logic, however, must, of course, be co-ordinated with other studies, and with the training of the powers of observation and mental discrimination as to the facts; for unless we make sure of the facts which constitute our premises, the use of the syllogism may only result in multiplying error instead of disclosing truth.

5. A further difficulty in education arises from the difficulty of obtaining good teachers, and in some cases from the practical impossibility of getting rid of poor ones. A large part of this difficulty is no doubt due to the enormous increase, within the past few decades, in the number of teachers required, corresponding to the remarkable growth of high schools and the enormous expansion of colleges and universities. For instance, in 1860 the number of high schools in the United States was 44; in 1870, 160; in 1880, 800; in 1890, 2,526, and in 1900, 6,005. In 1908 the number of teachers in our higher schools, including colleges, was about seven times what is was in 1870. There appears to be a real difficulty in obtaining competent teachers for high schools and colleges, particularly in view of the fact that the remuneration offered in this profession is much less than that which a capable man may expect to obtain in business or in one of the other professions.

If a man is not possessed of independent means, and if he wishes to marry and bring up a family comfortably, he will find the attractions of the teaching profession from this point of view very small. This is abundantly shown by the statistics recently given in an article in "Science" discussing the status of the assistant professor. The result is that many men probably go into teaching because they would not succeed in the world outside; and in technical subjects such men may often fail to give to the students the qualities necessary for success in the world.

Furthermore, in many of our institutions there seems to be little or no attempt made to appoint teachers with reference to their teaching ability, or subsequently to exercise any oversight over the conduct of their classes or the methods which they use. A man is appointed to a teaching position and is allowed to conduct his classes as he pleases. This is, of course, more true in some institutions than in others, but I believe that at least the criticism is well founded that not enough care is

taken by those in charge of our educational institutions or of the departments thereof, to see that really effective teaching is done.

On the one hand, the teacher may make things too plain to the students. When the student meets a difficulty, the teacher may be either so anxious to show that he understands how to solve it; or, in the kindness of his heart he may be so anxious to help the student, that he lifts him bodily over the difficulty without making him exercise his own powers at all. The only way that we become strong is by overcoming difficulties; we do not gain strength so long as our difficulties are overcome for us by others; yet this is too often done in teaching.

Or, it may be that the teacher is entirely unable to see the real difficulty in the mind of the pupil, and therefore, while he may try to explain it, he may only succeed in throwing more obscurity upon the subject.

I believe it would be desirable if the teachers in our institutions of learning would more often discuss among themselves—perhaps at stated meetings—the methods of teaching to be used; perhaps with the co-operation and criticism of some of the best students or recent graduates. It stands to reason, of course, that every teacher ought to have had some training in pedagogics; yet I believe that such training is rare in the teachers in our engineering schools, and it is perhaps too much to expect it. But it is not too much to expect that if they begin the career of teachers they should then devote some time to the study of the subject, or submit for a time, to careful oversight of their work. Unfortunately, academic freedom is too often interpreted to mean, not simply the freedom of students to do as they please, but the freedom of teachers to do the same entirely without criticism from any one; and some teachers who may be doing ineffective work would probably strongly resent any suggestion that they should change their methods. The result of this condition is that, in many institutions, courses may be found which have been given for years, which the best students and alumni would admit to be entirely unprofitable, and which, perhaps, the authorities of the institution know to be ineffective; and yet, with our present methods of university organization, there seems to be no way of remedying such a situation, any attempt to remedy it being considered either as arbitrary interference or a violation of the so-called educational democracy under which every man is allowed to do as he pleases.

Criticism of educational methods should, of course, always be kindly and it should also recognize the inherent difference between the conduct of education and the conduct of a business enterprise, that in the former individualism should be encouraged rather than suppressed. In corporation management it may be desirable or necessary to reduce the

work of the different departments to a rigid routine; while in education such a proceeding would be most unfortunate. Nevertheless, individualism should not be allowed to override the fundamental principles of pedagogics, nor be carried beyond reasonable limits. It must not be forgotten that the teacher is in a position where he can do not only much good, but much harm, and care should be taken that the latter is not the result of his efforts.

It is in regard to this phase of the question that the difference between the conduct of an institution of learning and of a business is perhaps most marked. In the latter there is a concentration of responsibility and a supervision of methods. A new president may entirely reorganize a railroad system, may cause the accounts to be kept in an entirely new manner, may readjust the relations of the different departments, may require the head of any department to have his work done in an entirely different way from that in which it had been done before, and all this without offense to any one. Such a method of procedure, even if necessary, would be likely to be considered nothing short of tyranny in an educational institution, and the limitations to acts of this kind have already been suggested; yet there should be some happy medium, some way by which the relations of teachers to each other, to the head of departments, and to the president, could be easily adjusted and without friction, in such a way that radical innovations might be brought about.

If a new university president has individual ideas, is there any good reason why he should not be enabled to carry them out, and why he should not be loyally supported in doing so, by trustees and faculty, even though his ideas are contrary to individual opinion? Until this can be done, until responsibility can be concentrated, and until means and methods are under practical control of the persons so made responsible, there will be no hope of obtaining the highest efficiency in education.

With reference to this matter I do not know of any more forceful statement than that made by Andrew S. Draper in his remarkable suggestive book on "American Education," in which he says:

"The very life of the institution depends upon eliminating weak and unproductive teachers, and upon reinforcing the teaching body with the very best in the world. Unless there is scientific aggressiveness in the search of new knowledge some very serious claims must be abandoned and some attitudes completely changed. No board ever got rid of a teacher or an investigator—no matter how weak or absurd—except for immorality known to the public. The reason why a board cannot deal with such a matter is the lack of individual confidence about what to do

and of individual responsibility for doing nothing. But, with three or four hundred in the faculty, the need of attention to this vital matter is always present. No board knows where new men of first quality are to be found; no board can conduct the negotiations for them, or fit them into an harmonious and effective whole. The man who is fitted for this great burden, and who puts his conscience up against his responsibility, can hardly be expected to tolerate the opposition of an unsubstantial sentiment which would protect a teacher at all hazards, or the more subtle combination of selfish influences which puts personal over and above public interests when the upbuilding of a university is the task in hand."

There is another point, however, in connection with the teachers which must never be lost sight of, and that is the responsibility of the institution to a teacher who has been kept in his position for a considerable length of time. Unlike the work of business, the work of teaching undoubtedly tends to unfit a man for other occupations. The average teacher is out of contact with business affairs and, as a rule, confined within the narrow limits of his educational activities. It is true, particularly in applied science, that many teachers have opportunities for doing a considerable amount of outside work and for building up a consulting practice, so that they are not wholly dependent upon their teaching, and if they should discontinue the latter they would still be able to find profitable employment. The number of such men, however, is comparatively few, and I think it is fair to say that the man who has remained in teaching for more than ten or fifteen years will generally find himself little adapted for anything else. In this lies the great importance of carefully scrutinizing the work of the young men in the teaching profession. An institution owes it to itself and to them to keep only the men who show conclusively their ability to succeed in the profession, and to get rid of the others before it is too late.

If the institution keeps men who are incompetent teachers, beyond the age when they are able to find other employment, it assumes a responsibility for providing for them in some way which it cannot shirk; yet it is very easy to keep a teacher in a subordinate position from mere force of habit or because no better man seems immediately available, although it might be easily foreseen that the time would come when for the good of the institution he ought to be replaced.

6. Another common defect in our teaching methods appears to be a lack of co-ordination. In many of our higher institutions, each teacher seems to be an unrestrained individual, following his own way, not only *teaching* his own subject in such manner as he pleases, but arranging his course and planning the ground to be covered without regard to anybody else. This criticism, if justified, is more apt to be applicable to our

colleges than to technical schools in which a required curriculum is prescribed and in which there must be a sequence of studies; but even in these there appears to be some room for improvement.

When absolute independence of teaching is combined with the lecture system, it may perhaps fairly be said that in many cases the students simply listen to the individual views of their teachers instead of being submitted to a systematic and continuous course of discipline, which would seem to be the main object of education. It stands to reason that there should be close coordination between all the subjects taught in any institution, so far as they are related to each other. There should be no over-lapping, except as this may, after definite consideration, be determined to be necessary or useful for purposes of repetition. One subject should naturally lead to another, and the sequence from the elementary to the difficult should be so continuous that no breaks should be perceptible. Whether the elective system or the prescribed curriculum is in use makes little difference, so long as each student is made to pass through a systematic course, involving continuous mental discipline.

Defects Due to Administration.

With reference to administration, the fundamental limitation to efficiency seems to me to lie in a fact which has already been referred to, namely, that the administrators—that is to say the trustees—have no financial interest at stake. This is the fundamental difference between the administration of a college and the administration of a business concern. Where men have no financial interest they cannot be expected to realize fully the responsibility, nor will they be apt energetically to take the necessary steps to insure efficiency.

For this reason, among others, I do not believe that education ever can be as efficient as business. I am not unmindful of the fact, of course, that there are many men who, if they accept positions on a board of college trustees, will take the same pains and feel the same responsibility as if they were trustees of a business corporation in which their own money as well as the funds of widows and orphans were invested; but this is somewhat contrary to human nature and must always be the exception. Money, or rather the love of it, may or may not be the root of all evil, but it certainly comes very near being the source of all efficiency.

This lack of concentration of responsibilty is found not only in boards of trustees, but through the whole educational staff. The system of faculty government is not conducive to it. Instead of one man being at the head of one branch of the work and being responsible for it, he is in some instances not allowed to carry out his own ideas even in matters which concerns his own branch alone, except in regard to the

subjects which he individually teaches. His views and perhaps those of the entire staff in his own branch, may be overborne by the votes in the faculty of men in entirely different branches who, perhaps, know little or nothing of the merits of the question involved.

Of course, this may in some instances prove a benefit, for heads of departments are not exempt from error, and are not always wise. The point is, that responsibility is divided, and if those upon whom responsibility is placed are, as they should be, equal to the task, a division of responsibility is always bad. Again, in the words of Dr. Draper, "University policies are not to be settled by majority vote. They are to be determined by expert opinion."

Nothing further need be said with reference to this phase of the question. Without concentration of responsibility, efficiency is undoubtedly diminished, and without direct financial interest, responsibility will not be heavily assumed. *When we combine a lack of direct financial interest in the product of education with the fact that the efficiency of the process is entirely intangible and incapable of any concrete expression, and the further fact that responsibility is divided, we have a combination which necessarily ensures a small percentage of efficiency—which constitutes its principal necessary limitation.*

I have endeavored to outline what the engineering graduate should be; what he unfortunately too often is; and have referred to some of the difficulties which are met in endeavoring to reach the ideal. Many of my remarks apply, of course, with even greater force to the college graduate also. The remedies, so far as remedies are possible, which have occurred to the writer have already been partially suggested. They may be summarized as follows:

1.—Every student in a university or technical school should be given systematic physical training, and instruction in physiology.

2.—Education should not be considered to be merely mental education. Moral development should be kept constantly in mind and every teacher should not only endeavor to make himself a moral example, but, as far as consistent, to inculcate moral lessons.

3.—Educational work is not consistent with such concentration of responsibility as is possible in business, but it should be striven after so far as possible.

4.—Every effort should be made to cause the student to see the necessity for self-discipline and self-exertion, to realize the value of his opportunities, the importance of cultivating proper mental, moral, and physical habits, the fact that his success will depend upon himself alone, the necessity of studying how to work *effectively* and not simply *earnestly*. If he does not reasonably appreciate these things and take advan-

tage of his opportunities, he should be promptly taken out of college and set to work earning his own living. Both parents and colleges are too lenient toward the indolent and the inefficient.

5.—Courses and examinations should be arranged, so far as possible, with the main object of training the student to observe and to think, and also, to a sufficient extent, to manipulate. It should be made impossible to pass in a course by rule-of-thumb work, mere memorizing, or cramming.

6.—The lecture system should be reduced to a minimum, so far as practicable.

7.—Students should be taught how to study, how to work effectively, and how to think logically. The systematic study of logic, in some form, might well be required in any engineering course.

8.—Teachers, at all events in the early portions of their careers, should be willing, and not only willing, but glad, to submit to some scrutiny of their methods and results, should welcome kindly criticism, should discuss and study educational methods, and should be willing to modify their own methods. There should be cordial sympathy and harmony between the members of the faculty, and a spirit of earnest cooperation.

9.—Every student should be obliged to follow a carefully planned curriculum, involving continuous and systematic mental discipline. This does not mean that every student should follow the same curriculum, but that each man's course should be systematic in itself.

10.—Students in colleges and technical schools should not idle away their summer vacations, but should devote them entirely or largely to work of some kind. The other vacations during the year are sufficient for the physical needs of boys of 18 or over. Summer work should be either at shop work or at summer engineering camps, or in actual shops or other engineering establishments, where the student will see the opportunities for the practical applications of science, and will also learn that ability and wisdom are not confined to men who go to college, and that if he would surpass the untutored man in the race of life it must be by getting an education.

But when all is said and done, the necessary limitations to efficiency in education will remain, these being largely due to the student himself and his lack of will, to the parent, who has given the boy no home discipline in the days of childhood, to the lack of financial incentive, and to the fact that efficiency cannot be measured.

Our colleges, no doubt, have serious defects—more serious on account of the extraordinary rapidity of their growth. But they are earnestly engaged in the attempt to solve a great problem. They may go

wrong, they undoubtedly will go wrong at times, but they will discover their mistakes and correct them so far as practicable. They need in many respects to be reformed, and where they need it they will be reformed. They have, on the whole, done much good work, together with considerable poor work, but they will do better and better work as the years go by.

THE RELATIONS OF CIVIL ENGINEERING TO OTHER BRANCHES OF SCIENCE.

By

Dr. J. A. L. Waddell.

Early in 1904 the Organizing Committee of the International Congress of Arts and Science which was founded under the auspices of the Louisiana Purchase Exposition invited Dr. Waddell and Prof. Lewis M. Haupt to represent the profession of civil engineering and address the Congress upon "The Relations of Civil Engineering to Other Branches of Science" and "Present Problems of Civil Engineering." Although the first of these addresses is of a rather abstract nature to claim deep interest from engineering students in general, still it contains much that can be read with profit by undergraduates of the higher grade, especially when they are truly interested in engineering as a learned profession. It is, therefore, hoped that it will prove to be both interesting and valuable to at least a few of the readers of this compilation of addresses.

Editors.

THE RELATIONS OF CIVIL ENGINEERING TO OTHER BRANCHES OF SCIENCE.

An Address to the International Congress of Arts and Science at the Universal Exposition, St. Louis, Mo., September 21, 1904.

By

Dr. J. A. L. Waddell.

The topic set for this address is "The Relations of Civil Engineering to Other Branches of Science." In its broad sense civil engineering includes all branches of engineering except, perhaps, the military. This is its scope as recognized by two of the highest authorities, viz., the American Society of Civil Engineers and the Institution of Civil Engineers of Great Britain; for these two societies of *Civil* Engineers admit to their ranks members of all branches of engineering. It is evident, though, from a perusal of the Programme of this Congress that the Organizing Committee intended to use the term in a restricted sense, because it has arranged for addresses on mechanical, electrical, and mining engineering. But what are the proper restrictions of the term is, up to the present time, a matter of individual opinion, no authority having as yet attempted definitely to divide engineering work among the various branches of the profession. To do so would, indeed, be a most difficult undertaking; for not only do all large constructions involve several branches of engineering, but also the profession is constantly being more minutely divided and subdivided. For instance, there are recognzied to-day by the general public, if not formally by the profession, the specialties of architectural, bridge, chemical, electrical, harbor, highway, hydraulic, landscape, marine, mechanical, metallurgical, mining, municipal, railroad, and sanitary engineering, and possibly other divisions; and the end is not yet, for the tendency of modern times in all walks of life is to specialize.

Between Tredgold's broad definition of civil engineering, which includes substantially all the applied sciences that relate to construction, and the absurdly narrow definition which certain engineers have lately been endeavoring to establish during the course of a somewhat animated discussion and which would confine civil engineering to dealing with stationary structures only, there must be some method of limitation that will recognize the modern tendency toward specialization without reducing the honored profession of civil engineering to a mere subdivision of applied mechanical science.

Without questioning in any way the correctness of the Tredgold definition, civil engineering will be assumed, for the purposes of this address, to include the design and construction of bridges; extensive and difficult foundations; tunneling; retaining walls; sea-walls and other heavy masonry; viaducts; wharves; piers; docks; river improvement; harbors and waterways; water supply; sewerage; filtration; treatment of refuse; highway construction; canals; irrigation works; dams; geodetic work; surveying; railways (both steam and electric); gas works; manufacturing plants; the general design and construction of plants for the production of power (steam, electric, hydraulic, and gaseous); the general design and construction of cranes; cableways; breakers, and other mining structures; the heavier structural features of office buildings and other large buildings that carry heavy loads; the general problems of transportation, quarrying, and the handling of heavy materials; and all designing and construction of a similar nature.

In contradistinction, mechanical engineering should include the design and construction of steam engines, machine tools, locomotives, hoisting and conveying machinery, cranes of the usual types, rolling-mill machinery, blast-furnace machinery, and, in fact, all machinery which is designed for purely manufacturing purposes.

Electrical engineering should include all essentially electrical work, such as the designing, construction, and operation of telephone and telegraph lines; electric light plants; dynamos; motors; switchboards; wiring; electric devices of all kinds; transmission lines; cables (both marine and land); and storage batteries.

Mining engineering should include all under-ground mining work; means for handling the products of mines; roasting, smelting, milling, stamping, and concentrating of ores; drainage and ventilation of mines; disposal of mine refuse; and similar problems.

It is impracticable to draw hard and fast lines between the various branches of engineering, because, as before indicated, nearly all large constructions involve several specialties, consequently no specialist can confine his attention to a single line of work to the exclusion of all other lines. For instance, the bridge engineer encounters mechanical and electrical engineering problems in designing movable bridges; railroading in approaches to bridges; river improvement in the protection of piers and abutments; highway construction in the pavement of wagon bridges; architecture in the machinery houses of swing spans; hydraulic engineering in guarding bridges against fire; and chemistry and metallurgy in testing materials. The railroad engineer encounters architecture and structural engineering in depots, roundhouses, and other buildings; hydraulic problems in pumping plants and bank protection; mechanical

engineering in interlocking plants; and electrical engineering in repair-shop machinery. The mining engineer invades the field of mechanical and electrical engineering in his hoisting, ventilating, and transporting machinery; deals with civil engineering in his surveys; and encounters chemistry and metallurgy in testing ores. Similarly it might be shown that all branches of engineering overlap each other and are interdependent.

It was the general opinion among scientists not many years ago that engineering was neither a science nor a profession, but merely a trade or business; and even to-day there are a few learned men who hold to this notion—some of them, *mirabile dictu,* being engineers; but that such a view is entirely erroneous is now commonly conceded. He is an ill-informed man who to-day will deny that civil engineering has become one of the learned professions. Its advances in the last quarter of a century have been truly gigantic and unprecedented in the annals of professional development. It certainly can justly lay claim to being the veritable profession of progress; for the larger portion of the immense material advancement of the world during the last century is due primarily and pre-eminently to its engineers.

It must be confessed that half a century ago engineering was little better than a trade, but by degrees it advanced into an art, and to-day, in its higher branches at least, it is certainly a science and one of the principal sciences.

The sciences may be divided into two main groups, viz., "Pure Sciences" and "Applied Sciences."

The "Pure Sciences" include:—

1st. Those sciences which deal with numbers and the three dimensions in space, the line, the surface, and the volume, or in other words "Mathematics."

2d. Those sciences which deal with inorganic matter, its origin, structure, metamorphoses, and properties; such as geology, petrology, chemistry, physics, mineralogy, geography, and astronomy.

3d. Those sciences which deal with the laws, structure, and life of organic matter; such as botany, zoology, entomology, anatomy, physiology, and anthropology.

4th. The social sciences; such as political economy, sociology, philosophy, history, psychology, politics, jurisprudence, education, and religion.

"Applied Sciences" include:—

1st. Those which relate to the growth and health of organic matter; such as medicine, surgery, dentistry, hygiene, agriculture, floriculture, and horticulture.

2d. Those which deal with the transformation of forces and inorganic matter, viz., the various lines of engineering,—civil, mechanical, electrical, mining, marine, chemical, metallurgical, architectural, etc.

3d. Those which relate to economics; such as industrial organizations and manufactures, transportation, commerce, exchange, and insurance.

Some writers make no distinction between the terms "Political Economy" and "Economics," but in this address they are divided, the former relating to broad subjects of national importance and the latter to minor matters and to some of the details of larger ones. For instance, currency, the national debt, banking, customs, taxation, and the subsidizing of industries pertain to "Political Economy," while economy of materials in designing and of cost of labor in construction, supplanting of hand power by machinery, systemization of work of all kinds, adjustment of grades and curvatures of railroads to traffic, and time and labor saving devices come under the head of "Economics."

The distinctions between the pure and the applied sciences are at times extremely difficult to draw, for one science often merges almost imperceptibly into one or more of the others..

The groups of pure sciences that have been enumerated may be termed

The Mathematical Sciences,
The Physical Sciences,
The Physiological Sciences, and
The Social Sciences,
while the groups of applied sciences may be called
The Organic Sciences,
The Constructive Sciences, and
The Economic Sciences.

In what follows the preceding nomenclature will be adopted.

The terming of engineering the "Constructive Science" is a happy conception, for engineering is truly and almost exclusively the science of construction. The functions of the engineer in all cases are either directly constructive or tend toward construction.

The engineer has ever had a due appreciation of all the sciences, imagination to see practical possibilities for the results of their findings, and the common-sense power of applying them to his own use.

Pure science (barring perhaps political economy) is not concerned with financial matters, and its devotees often look down with lofty disdain upon everything of a utilitarian nature, but engineering is certainly the science most directly concerned with the expenditure of money. The engineer is the practical man of the family of scientists. While he is

sufficiently well informed to be able to go up into the clouds occasionally with his brethren, he is always judicious and comes to earth again. In all his thoughts, words, and acts he is primarily utilitarian. It is true that he bows down to the goddess of mathematics, but he always worships from afar. It is not to be denied that mathematics is the mainstay of engineering; nevertheless the true engineer pursues the subject only so far as it is of practical value, while the mathematician seeks new laws and further development of the science in the abstract. The engineer does not trouble himself to consider space of four dimensions, because there are too many things for him to do in the three-dimension space in which he lives. Non-Euclidian geometry is barred from his mind for a fuller understanding of the geometry which is of use to ordinary mankind. The mathematician demonstrates that the triangle is the sole polygonal figure which cannot be distorted, while the engineer, recognizing the correctness of the principle, adopts it as the fundamental, elementary form for his trusses. The mathematician endeavors to stretch his imagination so as to grasp the infinite, but the engineer limits his field of action to finite, tangible matters.

The geologist, purely studious, points out what he has deduced about the construction of the earth; but the engineer makes the mine pay.

The chemist discovers certain facts about the effects of different elements in alloys; but the engineer works out and specifies a new material for his structures. Again, the chemist learns something about the action of clay combined with carbonate of lime when water is added, and from this discovery the engineer determines a way to produce hydraulic cement.

The physicist evolves the theory of the expansive power of steam, and the engineer uses this knowledge in the development of the steam engine. Again, the physicist determines by both theory and experiment the laws governing the pressures exerted by liquids, and the engineer applies these laws to the construction of dams and ships.

The botanist with his microscope studies the form and construction of woods, while the engineer by experimentation devises means to preserve his timber.

The biologist points to bare facts that he has discovered, but the engineer grasps them and utilizes them for the purification of water supplies.

In short, the aim of pure science is discovery, but the purpose of engineering is usefulness.

The delvers in the mysterious laboratories, the mathematical gymnasts, the scholars poring over musty tomes of knowledge, are not understood by the work-a-day world, nor do they understand it. But

between stands the engineer with keen and sympathetic appreciation of the value of the work of the one and a ready understanding of the needs and requirements of the other; and by his power of adaptability he grasps the problem presented, takes from the investigators their abstract results, and transforms them into practical usefulness for the world.

The work of the engineer usually does not permit him to make very extensive researches or important scientific discoveries; nor is it often essential today for him to do so, as there are numerous investigators in all lines whose object is to deduce abstract scientific facts; nevertheless there comes a time occasionally in the career of every successful engineer when it is necessary for him to make investigations more or less abstract, although ultimately utilitarian; consequently it behooves engineers to keep in touch with the methods of scientific investigation, in order that they may either perform desired experiments themselves, or instruct trained investigators how to perform them.

The engineer must be more or less a genius who invents and devises ways and means of applying all available resources to the uses of mankind. His motto is "utility," and his every thought and act must be to employ to the best advantage the materials and conditions at hand. To be able to accomplish this object he must be thoroughly familiar with all useful materials and their physical properties as determined by the investigations of the pure scientists.

Many well known principles of science have lain unused for ages awaiting the practical application for which they were just suited. The power of steam was known long before the practical mind of Watt utilized it in the steam engine.

The engineer is probably an evolution of the artisan rather than of the early scientist. His work is becoming more scientific because of his relations and associations with the scientific world. These relations of the engineer to the sciences are of comparatively recent origin, and this fact accounts for the rapid development in the engineering and industrial world of the past half century. The results of this association have been advantageous to both the engineer and the pure scientist. The demands of the engineers for new discoveries have acted as an incentive for greater effort on the part of the investigators. In many instances the engineer is years in advance of the pure scientist in these demands; but, on the other hand, there are, no doubt, many valuable scientific facts now available which will yet work wonders when the engineer perceives their practical utility.

The engineer develops much more fully the faculty of discernment than does the abstract scientist, he is less visionary and more practical, less exacting and more commercial.

It is essential to progress that large stores of scientific knowledge in the abstract be accumulated and recorded in advance by the pure scientists, so that as the engineer encounters the necessity for their use he can employ them to the best advantage. The engineer must be familiar with these stores of useful knowledge in order to know what is available. This forms the scientific side of the engineer's work. While he must know what has been done by investigators, it is not absolutely necessary that he know how to make all such researches for himself; although, as before stated, there are times in an engineer's practice when such knowledge will not come amiss.

As engineers are specializing more and more, each particular specialty becomes more closely allied with the sciences that most affect it; consequently, to ensure the very best and most enconomic results in his work the engineer must keep in close touch with all of the scientific discoveries in his line.

The early engineers, owing to lack of scientific knowledge, took much greater chances in their constructions than is necessary for up-to-date modern engineers. There is now no occasion for an engineer to make any hazardous experiments in his structures, because by careful study of scientific records he can render his results certain.

In future the relations between engineers and the pure scientists will be even closer than they are today, for as the problems confronted by the engineer become more complex and comprehensive the necessity for accurate knowledge will increase.

The technical training now given engineers involves a great deal of the purely scientific; and it is evident that this training should be so complete as to give them a comprehensive knowledge of all the leading sciences that affiliate with engineering. There is no other profession that requires such a thorough knowledge of nature and her laws.

Of all the various divisions and sub-divisions of the sciences hereinbefore enumerated and of those tabulated in the Organizing Committee's "Programme," the following only are associated at all closely with civil engineering:—

Mathematics.
Geology.
Petrology.
Chemistry.
Physics.
Mineralogy.
Geography.
Astronomy.
Biology.

Botany.
Political Economy.
Jurisprudence.
Education.
Economics.

Attention is called to the fact that this list contains a number of divisions from the four main groups of pure sciences, viz., the mathematical, physical, physiological, and social, and but one division (economics) from the three groups of applied sciences, viz., the organic, constructive, and economic. The reasons why so little attention is to be given to the relation between civil engineering and the applied sciences are, first, in respect to organic science, there is scarcely any relation worth mentioning between this science and civil engineering, and, second, because the inter-relations between civil engineering and other divisions of constructive science have already been treated in this address.

Of all the pure sciences there is none so intimately connected with civil engineering as mathematics. It is not, as most laymen suppose, the whole essence of engineering, but it is the engineer's principal tool. Because technical students are drilled so thoroughly in mathematics and because so much stress is laid upon the study of calculus, it is commonly thought that the higher mathematics are employed constantly in an engineer's practice; but, as a matter of fact, the only branches of mathematics that a constructing engineer employs regularly are arithmetic, geometry, algebra, and trigonometry. In some lines of work logarithms are used often, and occasionally in establishing a formula the calculus is employed; but the engineer in active practice soon pretty nearly forgets what analytical geometry and calculus mean. As for applied mechanics, which, as the term is generally understood, is a branch of mathematics (although it involves also physics and other sciences), the engineer once in a while has to take down his old textbooks to look up some principle that he has encountered in his reading but has forgotten. Strictly speaking, though, engineers in their daily tasks utilize applied mechanics, almost without recognition; for stresses, moments, energy, moments of inertia, impact, momentum, radii of gyration, etc., are all conceptions of applied mechanics; and these are terms that the engineer employs constantly.

There are some branches of the higher mathematics of which as yet engineers have made no practical use, and prominent among these is quaternions. When it first appeared the conciseness of its reasoning and its numerous short-cuts to results gave promise of practical usefulness to engineers, but thus far the promise has not been fulfilled.

Notwithstanding the fact that the higher mathematics are of so little use to the practicing engineer, this is no reason why their study should be omitted from or even slighted in the technical schools; because when an engineer has need in his work for the higher mathematics he needs them badly; besides, the mental training that their study involves is almost a necessity for an engineer's professional success.

Geology (with its allied branch, or more strictly speaking subdivision, petrology) and civil engineering are closely allied. Civil engineers are by no means so well versed in this important science as they should be. This, perhaps, is due to the fact that the instruction given on geology in technical schools is mainly from books, hence most graduates find difficulty in naming properly the ordinary stones that they encounter, and are unable to prognosticate with reasonable assurance concerning what a proposed cutting contains.

Geology is important to the civil engineer in tunneling, railroading, foundations, mining, water-supply, and many other lines of work; consequently, he needs to receive at his technical school a thorough course in the subject given both by text-books and by field instruction.

A knowledge of petrology will enable the engineer to determine readily whether building stone contains iron which will injure its appearance on exposure, or feldspar which will disintegrate rapidly under the action of the weather or of acids from manufacturing establishments.

Next to mathematics, physics is undoubtedly the science most essential to civil engineering. The physicist discovers and formulates the laws of nature, the engineer employs them in "directing the sources of power in nature for the use and convenience of man." The forces of gravitation, adhesion, and cohesion; the pressure, compressibility, and expansibility of fluids and gases; the laws of motion, curvilinear, rectilinear, accelerated, and retarded; momentum; work; energy; the transformation of energy; thermodynamics; electricity; the laws of wave motion; the reflection, refraction, and transmission of light; and the mass of other data furnished by the physicist form a large portion of the first principles of civil engineering.

The function of applied mechanics is to establish the fundamental laws of physics in terms suitable for service, and to demonstrate their applicability to engineering construction.

Chemistry is a science that enters into closer relations with civil engineering than does any other science except mathematics and physics, and as the manufacture of the materials of engineering approaches perfection the importance of chemistry to engineers increases. Within a comparatively short period the chemist has made it possible by analyz-

ing and selecting the constituents to control the quality of cast iron, cast steel, rolled steel, bronze, brass, nickel steel, and other alloys. The engineer requires certain physical characteristics in his materials, and obtains them by limiting the chemical constituents in accord with data previously furnished by the chemist. The proper manufacture of cement requires the combined skill and knowledge of the chemist and the mechanical engineer.

In water supply the chemist is called in to determine the character and amounts of the impurities in the water furnished or contemplated for use. The recent discovery that the introduction of about one part of sulphate of copper in a million parts of water will effectively dispose of the algæ, which have long given trouble, is a notable instance of the increasing interdependence of these two branches of science, as is also the fact that the addition to water of a small amount of alum will precipitate the earthy matter held in suspension without leaving in it any appreciable trace of the reagent.

In the purification of water and sewage, in the selection of materials which will resist the action of acids and the elements, and in the manufacture of alloys to meet various requirements, a thorough knowledge of chemistry is essential.

A knowledge of mineralogy is requisite for a clear understanding of the nature of many materials of construction, but is otherwise of only general interest to civil engineers.

Geography in its broad sense is related to civil engineering in some of its lines, for instance, geodesy and surveying, but generally speaking there is not much connection between these two branches of science.

Astronomy is perhaps more nearly related to civil engineering than is geography, although it is so related in exactly the same lines, for the railroad engineer on a long survey must occasionally check the correctness of his alignment by observations of Polaris, and the coast surveyor locates points by observations of the heavenly bodies.

Biology is allied to civil engineering mainly through bacteriology as applied to potable water, the treatment of sewage to prevent contamination of streams, and the sanitation of the camps of surveying and construction parties. The treatment of sewage has been given much more thorough study abroad than in this country, but the importance of its bearing upon life in the large cities of America is becoming better understood; consequently the progressive sanitary engineer should possess a thorough knowledge of bacteriology. In important cases, such as an epidemic of typhoid fever, the specialist in bacteriology would undoubtedly be called in; but a large portion of the work of pre-

venting or eradicating bacterial diseases will fall to the lot of the sanitary engineer.

Botany comes in touch with civil engineering mainly, if not solely, in the study of the various woods used in construction, although it is a fact that a very intimate knowledge of this pure science might enable a railroad engineer or surveyor to determine approximately the characters of the soils from the plants and trees growing upon them. A knowledge of botany is of no great value to the civil engineer, and much time is often wasted on its study in technical schools.

Political economy is a science that at first thought one would be likely to say is not at all allied to civil engineering; but if he did so, he would be mistaken, because political economy certainly includes the science of business and finance, and civil engineering is most assuredly a business as well as a profession; besides the leading engineers usually are either financiers themselves or advisers to financiers. Great enterprises are often evolved, studied, financed, and executed by engineers. How important it is then that they understand the principles of political economy, especially in their relations to engineering enterprises! It is only of late years that technical students have received much instruction in this branch of social science, and the ordinary technical school curriculum today certainly leaves much to be desired in respect to instruction in political economy.

Jurisprudence and civil engineering are closely allied, in that engineers of all lines must understand the laws of business and the restrictions that are likely to be placed upon their constructions by municipal, county, state, and federal laws. While most engineering schools carry in their list of studies the "Laws of Business," very few of them devote anything like sufficient attention to this important branch of science.

Are the sciences of civil engineering and education in any way allied? Aye, that they are! and far more than most people think, for there is no other profession that requires as much education as does civil engineering. Not only must the would-be engineer study the various pure and applied sciences and learn a great mass of technical facts; but he must also have in advance of all this instruction a broad, general education—the broader the better, provided that no time be wasted on useless studies, such as the dead languages.

The science of education is so important a subject for civil engineers that all members of the profession in North America, more especially those of high rank, ought to take the deepest interest in the development of engineering education, primarily by joining the special society organized for its promotion, and afterward by devoting some of their

working time to aid this society in accomplishing its most praiseworthy objects.

The science of economics and that of civil engineering are, or ought to be, in the closest possible touch; for true economy in design and construction is one of the most important features of modern engineering. Every high-class engineer must be a true economist in all the professional work that he does, for unless one be such, it is impossible today for him to rise above mediocrity.

True economy in engineering consists in always designing and building structures, machines, and other constructions so that, while they will perform satisfactorily in every way all the functions for which they are required, the sum of their first cost and the equivalent capitalized cost for their maintenance, operation, and repairs shall be a minimum. The ordinary notion that the structure or machine which is least in first cost must be the most economical is a fallacy. In fact, in many cases, just the opposite is true, the structure or machine involving the largest first cost being often the cheapest.

Economics as a science should be taught thoroughly to the student in the technical school, then economy in all his early work should be drilled into him by his superiors during his novitiate in the profession, so that when he reaches the stage where he designs and builds independently, his constructions will invariably be models of true economy.

It has been stated that the relations between civil engineering and many of the pure sciences are very intimate, that the various branches of engineering, although becoming constantly more and more specialized, are so interdependent and so closely connected that they cannot be separated in important constructions, that the more data the pure scientists furnish the engineers the better it is for both parties, and that a broad, general knowledge of many of the sciences, both pure and applied, is essential to great success in the engineering profession.

Such being the case, the question arises as to what can be done to foster a still closer affiliation between engineering and the other sciences, and how engineers of all branches and the pure scientists can best be brought into more intimate relations, in order to advance the development of the pure sciences, and thus benefit the entire world by increasing the knowledge and efficiency of its engineers.

One of the most effective means is to encourage the creation of such congresses as the one that is now being held, and so to organize them and arrange their various meetings as to secure the greatest possible beneficial results.

Another is for such societies as the American Association for the Advancement of Science and the Society for the Promotion of Engi-

neering Education to take into their membership engineers of good standing, and induce them to share the labors and responsibilities of the other members.

Conversely, the various technical societies should associate with them by admission to some dignified grade (other, perhaps, than that of full member) pure scientists of high rank and specialists in other branches of constructive science, and should do their best to interest such gentlemen in the societies' objects and development.

A self-evident and most effective method of accomplishing the desired result is to improve the courses of study in the technical schools in every possible way; for instance, by bringing prominent scientists and engineers to lecture to the students and to tell them just how scientific and professional work of importance is being done throughout the world, by stimulating their ambition to rise in their chosen profession, by teaching them to love their work instead of looking upon it as a necessary evil, and by offering prizes and distinctions for the evidence of superior and effective mental effort on the part of both students and practicing engineers.

There has lately been advanced an idea which, if followed out, would aid the development of engineering more effectually than any other possible method, and incidentally it would bring into close contact scientists in all branches related directly or indirectly to engineering. It is the establishment of a great post-graduate school of engineering in which should be taught in every branch of the profession the most advanced subjects of all existing knowledge that is of real, practical value, the instructors being chosen mainly from the leading engineers in each specialty, regardless of the cost of their services. Such specialists would, of course, be expected to give to this teaching only a few weeks per annum, and a corps of regular professors and instructors who would devote their entire time and energies to the interests of the school would be required. These professors and instructors should be the best that the country possesses, and the inducements of salary and facilities for investigation that are provided should be such that no technical instructor could afford to refuse an offer of a professorship in this school.

Every modern apparatus needed for either instruction or original investigation should be furnished; and arrangements should be made for providing means to carry out all important technical investigations.

It should be the duty of the regular faculty to make a special study of engineering literature for the benefit of the profession; to prepare annual indices thereof; to put into book form the gist of all technical writings in the transactions of the various engineering societies and in

the technical press that are worthy of being preserved and recorded in this way, so that students and engineers shall be able to search in books for all the data they need instead of in the back files of periodicals; to translate or assist in the translation of all engineering books in foreign languages, which, in the opinion of competent experts, would prove useful to engineers or to the students of the school; and to edit and publish a periodical for the recording of the results of all investigations of value made under the auspices of the institution.

In respect to what might be accomplished by such a post-graduate school of engineering, the following quotation is made from the pamphlet containing the address in which the project was advanced:-*

"The advantages to be gained by attendance at such a post-graduate school as the one advocated are almost beyond expression. A degree from such a school would always ensure rapid success for its recipient. Possibly for two or three years after taking it a young engineer would have less earning capacity than his classmates of equal ability from the lower technical school, who had gone directly into actual practice. However, in five years he certainly would have surpassed them, and in less than ten years he would be a recognized authority, while the majority of the others would be forming the rank and file of the profession, with none of them approaching at all closely in reputation the more highly educated engineer.

"But if the advantages of the proposed school to the individual are so great, how much greater would be its advantages to the engineering profession and to the entire nation! After a few years of its existence there would be scattered throughout the country a number of engineers more highly trained in the arts and sciences than any technical men who have ever lived; and it certainly would not take long to make apparent the impress of their individuality and knowledge upon the development of civil engineering in all its branches, with a resulting betterment to all kinds of constructions and the evolution of many new and important types.

"When one considers that the true progress of the entire civilized world is due almost entirely to the work of its engineers, the importance of providing the engineering profession with the highest possible education in both theoretical and practical lines cannot be exaggerated.

"What greater or more worthy use for his accumulated wealth could an American multi-millionaire conceive than the endowment and establishment of a post-graduate school of civil engineering?"

*Higher Education for Civil Engineers. An Address to the Engineering Society of the University of Nebraska, April 8, 1904, by J. A. L. Waddell, D. Sc., LL. D., D. E.

Another extremely practical and effective means for affiliating civil engineering and the other sciences is for engineers and professors of both pure science and technics to establish the custom of associating themselves for the purpose of solving problems that occur in the engineers' practice. Funds should be made available by millionaires and the richer institutions of learning for the prosecution of such investigations.

Another possible (but in the past not always a successful) method, is the appointment by technical societies of special committees to investigate important questions. The main trouble experienced by such committees has been the lack of funds for carrying out the necessary investigations, and the fact that in nearly every case the members of the committees were unpaid except by the possible honor and glory resulting from a satisfactory conclusion of their work.

Finally, an ideal but still practicable means is the evolution of a high standard of professional ethics, applicable to all branches of engineering, and governing the relations of engineers to each other, to their fellow workers in the allied sciences, and to mankind in general.

As an example of what may be accomplished by an alliance of engineering and the pure sciences, the construction of the proposed Panama Canal might be mentioned. Some years ago the French attempted to build this waterway and failed, largely on account of the deadly fevers which attacked the workmen. It is said that at times the annual death rate on the work ran as high as six hundred per thousand. Since the efforts of the French on the project practically ceased, the sciences of medicine and biology have discovered how to combat with good chances for success the fatal malarial and yellow fevers, as was instanced by the success of the Americans in dealing with these scourges in the City of Havana after the conclusion of the Spanish-American war.

The success of the American engineers in consummating the great enterprise of excavating a navigable channel between the Atlantic and Pacific Oceans (and concerning their ultimate success there is almost no reasonable doubt) will depend largely upon the assistance they receive from medical science and its allied sciences, such as hygiene, bacteriology, and chemistry.

Geological science will also play an important part in the design and building of many portions of this great work, for a comprehensive and correct knowledge of the geology of the Isthmus will prevent the making of many costly mistakes, similar to those that resulted from the last attempt to connect the two oceans.

Again, the handling of this vast enterprise will involve from start to finish and to an eminent degree the science of economics. That this science will be utilized to the utmost throughout the entire work is assured by the character and professional reputation of both the Chief Engineer and the members of the Commission.

Notwithstanding, though, the great precautions and high hopes for a speedy and fortunate conclusion of the enterprise with which all concerned are starting out, many unanticipated difficulties are very certain to be encountered, and many valuable lives are likely to be expended on the Isthmus before the first steamer passes through the completed canal. Engineering work in tropical countries always costs much more and takes much longer to accomplish than is first anticipated; and disease, in spite of all precautions, is very certain to demand and receive its toll from those who rashly and fearlessly face it on construction works in the *tierra caliente*. But with American engineers in charge, and with the finances of the American Government behind the project, success is practically assured in advance.

What the future of civil engineering is to be, who can say? If it continues to advance as of late by almost geometrical progression, the mind of man can hardly conceive what it will become in fifty years more! Every valuable scientific discovery is certainly going to be grasped quickly by the engineers and put to practical use by them for the benefit of mankind, and it is only by their close association with the pure scientists that the greatest possible development of the world can be attained.

COLLEGE TRAINING OF ELECTRICAL ENGINEERS.

By

Dr. Arthur C. Scott.

This paper, which was published in the *Electrical World* of April 18, 1908, is partially reproduced here, primarily, because of its real value and, secondarily, to give representation to the electrical branch of engineering.

The Editors endorse heartily Dr. Scott's plea for a longer time in which to give electrical engineering courses; and they consider that the said plea applies equally well to the curricula of all other branches of engineering instruction.

Dr. Scott was born at Belmont, N. Y., August 31, 1873. A few months later his father removed to Summit, R. I., and there and in the city of Providence Dr. Scott spent his early youth attending school and taking an active part in his father's manufacturing business, thus early acquiring facility in the use and care of machinery. From 1888 to 1890 he taught school, and after a further year of active business, he entered the Rhode Island College of Agriculture and Mechanic Arts, graduating therefrom with honors in 1895. During his senior year he served as Instructor in Chemistry. Immediately on graduation he was appointed Instructor in Physics, and served as such until 1879, when he was made Professor in the same subject. During these years he developed a course in Electrical Engineering to follow a two years' course in Physics. He also took charge of the steam heating and lighting plant of the institution and improved it. At the same time, during summer vacations, he pursued courses in Physics, Engineering, Mathematics, and Geology at Harvard University, Clark University, Cornell University, and Massachusetts Institute of Technology.

In the summer of 1901, having received leave of absence from Rhode Island College, he began resident graduate work in Electrical Engineering, Physics, and Geology at the University of Wisconsin, completing the same with the degree of Ph. D. in August, 1902, his thesis being entitled "An Investigation of Rotations Produced by Current from a Single-Phase Alternator."

Returning to Rhode Island College in the fall of 1902, he reorganized the courses in Electrical Engineering, and was actively engaged in

their further development when called to the University of Texas in 1904 to take the chair of Electrical Engineering.

Quite lately Dr. Scott has severed his connection with the University and has entered into private practice as a consulting engineer at Austin, Texas. At present he is occupied with the rebuilding of the Austin dam and several other Texas power plants.

Dr. Scott's literary work thus far has been confined to the writing of a number of important scientific papers for the technical press; but it is to be hoped that some day he may present in book form to the engineering profession the results of some of his valuable investigations.

Editors.

COLLEGE TRAINING OF ELECTRICAL ENGINEERS.

By

Dr. Arthur C. Scott.

Lord Kelvin said that the first object of an education is "to enable a man to live," and the second, "to assist other men to live." The truthfulness of this statement is nowhere more apparent than when considered with respect to the engineer of the present time; to him is due, more than to any other, the great improvements in communication, transportation, illumination, and sanitation, which so manifestly assist other men to live. Moreover, it must be admitted that the phenomenal advance made in electrical engineering within the past few years has brought comforts and luxuries to the public at large never before considered possible.

It has been well said that "the recent rapid development of the electrical industry owes its vitality to the engineering school. Its graduates have done the designing, constructing, operating, and directing which have made possible the rapid progress and wise extension in the use of electricity."

Granting that this is true, the questions of vital interest and importance at present are:

Does the average university or college technical school properly prepare its students for their life work as engineers?

Does the sequence of courses taught, and do the methods of teaching afford the maximum opportunity for the student, when viewed from a common meeting point of the psychological and pedogogical standards within the college, and the practical or operating standards outside it?

Such questions as these, or something akin to them, have of late been the source of voluminous, and no doubt profitable discussion, although a digest of papers recently published in the American Institute transactions, the Electrical World and the proceedings of the Society for the Promotion of Engineering Education, appears to show that no common ground of agreement has yet been reached.

A few years ago the manufacturers and heads of corporations gave the college graduate but little encouragement because they did not appreciate the value of concentrated theory; the probable reason why today they are saying, "Give us technically educated men," and are filling vacancies in their factories and systems with college men, is

on the one hand that the college is constantly endeavoring to improve methods of instruction, including such practical testing and laboratory work as will be more in line with their requirements, and on the other, the manufacturer or corporation manager is becoming educated to recognize the importance of sound theoretical training.

The most potent criticisms by large manufacturers and property managers of their college graduate employees, at the present time, appears to be that they lack a certain kind of human common sense, and that they do not know how to adapt themselves to new conditions, or to adjust their personalities to the wishes of their superiors; that they lack most decidedly the ability to direct men and are loath to assume responsibility which requires originality or initiative on their part.

To meet such deficiencies several of the large concerns have established special apprenticeship courses, and it has recently been shown that with one large company, of those who finished the apprenticeship course, 50 per cent are now with the company, and the others are with operating or electrical supply companies, or acting as consulting engineers or instructors.

The apprenticeship course attests the validity of the criticism, but there are grades of adverse criticism, and it appears that the sort presented is the best, for the following reason: A student passes from three or four years of cramming, memorizing effort in the high school to the college. During the first two years of his college course he is likely to go on memorizing as in the high school, and does not really learn how to study or concentrate his mind on the work before him until some time during the junior year, or possibly the senior year. As a matter of fact, it appears that there is not sufficient time for him to obtain a knowledge of the fundamental principles underlying a broad education in engineering, and at the same time carry on work involving much originality, or the direction of men. Therefore, the criticism of the manufacturers in general of college graduates is what one familiar with professional college work might expect. There appears to be no doubt, however, in the minds of all that fundamental principles of mathematics, mechanics, physics, chemistry, English, foreign languages, and political science are a necessary part of the engineering graduate's proper training, as well as the more specialized subjects of engineering.

One writer representing a large manufacturing company says: "Engineering students usually hate rhetoricals and language courses. They should remember that engineers are sometimes called upon to fill positions which are worth more than $75 per month, and that in such positions they will need to know how to speak and write the English language."

In attempting then to answer the question as to whether the average university or college technical school properly prepares its students for their life work as engineers, a noteworthy distinction should be made between the technical courses of the colleges and the technical courses of the trades schools. While the latter may take the student as far in the strictly technical subjects of engineering as do the college courses, these schools do not assume to spend any time upon the so-called culture studies that are required in college courses in engineering. If the culture studies were removed from the college courses, there would be more time available for the student to develop originality in his work and possibly to obtain some instruction concerning the direction of men, and commercial accounting.

Under these conditions, however, he is likely to become narrow-minded concerning his work; he gains nothing socially which a knowledge of the culture studies may accord him; he is limited to a direct line of work because he has insufficient training to give him the confidence in himself to start in any other. His earning capacity "in the long run" is decreased proportionally, as has been well shown by statistics collected some time ago by James M. Dodge.

It appears that it is unwise for the university technical school to attempt to go much farther toward the manufacturers in attempting to turn out students who shall just suit them at the start. In the first place it is impossible to graduate men who would suit the requirements of all the manufacturers or employers. Methods are different in different places, and require time and attention spent on them by anyone, whether student or not, before he is in a position to show much originality or power of direction.

It stands to reason that the *general aim* of the courses of the average technical college at the present time is commendable; namely, the thorough training of the student in all subjects fundamental to engineering, with the introduction of such culture subjects as will serve to place the student on an even footing, intellectually and socially, with men in other professions, and in so far as this result is accomplished the college directs its students in the proper way. In other words, the graduates have the rudiments of their profession, and the essentials of cultured citizens: personal characteristics, environment, and time are depended upon for final results.

The time is at hand, however, when the engineer should be so educated as to appreciate the artistic possibilities in his product, and to exhibit esthetic sense in design. When the great engineering feats of today become the ordinary products of tomorrow, the public will demand beauty of design, as well as rigidity and utility of construc-

tion and installation. And when the demand is made the men who have finished an A. B. course in the university, followed by a full engineering course, will occupy first positions because of the important cultural training which they possess.

I am thoroughly of the opinion, therefore, that the average technical college does not *properly* prepare students for their future work as electrical engineers. The chief reason is that an attempt is made to complete subjects in a four-year course, which, if properly taught, would require fully six years. It is no wonder the student does not develop the spirit of original research—he has no time to do anything but attend lectures in the morning and laboratory practice in the afternoon for six days per week, and even at that pace does not properly cover the ground. The electrical engineer must be more of an all-round engineer than any other; he must not only have the fundamental knowledge of theoretical and applied electricity, but in addition must be reasonably familiar with much of civil, steam, hydraulic, and gas engineering.

Moreover, he should have some general instruction concerning the public service corporation methods of the division of labor, accounting, and general policy toward the public; on the law of contracts; and on the interpretation of specifications and plans concerning both buildings and equipment.

Many of the universities are recognizing the fact that the engineers are doing from one-third to one-half more work during the four years taken to graduate than are the academic students. This, of course, is largely due to the relatively great number of hours spent in the laboratory, and commendable changes are already being made in several technical colleges, substituting a five or six-year course for the four-year course heretofore required.

With the ever-increasing additions to the present great store of technical knowledge, I have no hesitancy in expressing my belief that the institutions that are in the lead with a five or six-year technical course will readily find better positions for their graduates than will the others. It certainly appears reasonable that in an institution having well-equipped laboratories and a corps of competent instructors, it is possible for the student during the one or two extra years to do much more for himself than would be possible in the same time after leaving at the end of a four-year course with what amounts to a too hastily swallowed dose of everything taken; this is evidenced not infrequently by cases of acute mental indigestion and, as complained of by the manufacturers, an utter lack of originality, judgment, or logic in meeting shop requirements.

The longer course gives the student time for some attention to athletics, social functions, perusal of current engineering literature, a better training in culture subjects and a much more thorough training in theoretical and applied engineering, than a four-year course. My view of the situation, considering the best interests of the students, is that any college offering technical courses leading to an electrical engineering degree, should require the equivalent of a five-year course to obtain the B. Sc. degree in electrical engineering, with the further provision that the E. E. degree be allowed for an additional year of study involving a thesis covering original research work; maintaining the standard entrance requirements as at present and the same for all students.

I venture to presume that the two additional years thus covered by the student in the university would be of more benefit to him eventually than the first five years following the completion of a four-year course if spent elsewhere.

The answer to the first question involves to some extent the answer to the second. It is evident, if the presumption be granted that four years is too short a time for the college man to complete an electrical engineering course, that the methods of teaching might be improved. It does not necessarily follow, however, that an increase of time required would involve a change in sequence of subjects.

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So far as laboratory courses are concerned, I believe it to be possible to meet the criticisms of employers of students to some extent. In some of the engineering laboratories the students have nearly all connections made for them, and their chief duty, one and all, in a test is to read instruments and record their readings. I think that is the limit of poor laboratory instruction. The student regards it as a special dispensation at the time, but if he is required to direct a shop test later on, he will no doubt act as though devoid of "human common sense." He does not know what to do, much less how to direct others. The laboratory course that will most nearly meet the adverse criticism of employers today is the one wherein the students are required to make all machine and instrument connections, and also that requires some one of the members of a section to act as director of the test at every period, and be responsible to a reasonable extent for the use of machines and instruments. This arrangement is not intended to relieve the instructor from his duties in the least; on the contrary, it may add something to them, for the student whose turn it may be to direct the test should confer with him beforehand in order to be sure that he

understands the test completely, and also to learn what instruments are available for the test.

It is only by actually directing men that one learns how to do it, and if the students gain some practice in this way in the laboratory, they may be less criticised after entering practical work.

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To sum up, then, finally:

(1) The demands of present-day electrical engineering are such as to make the extension of the normal college course of four years to five years highly desirable.

(2) To stimulate the interest of the students in professional engineering early in their college course, and to bring the students into contact with professional electrical engineers, the head of the school or an associate professor should give a course in electrical engineering physics to first-year men.

(3) Conference hours should be held in connection with theoretical work; one conference hour for each two or three hours' lectures to juniors and seniors on engineering subjects.

(4) Laboratory courses in electrical engineering strictly, should require the students to arrange all connections to instruments and machines in the electrical laboratories, or the connecting of all auxiliary apparatus for tests in steam or gas engineering laboratories, together with the direction of the section on each test performed by some one of the section previously designated by the instructor.

Such changes, I believe, would materially assist the engineering students to attain the scholarship rank of students in other university departments and also more successfully to meet the demands of commercial practice.

THE PRESENT STATUS OF THE ENGINEERING PROFESSION AND HOW IT MAY BE IMPROVED.

By

Dr. J. A. L. Waddell.

This address was delivered on January 18, 1911, at the University of Nebraska on the occasion of the dedication of its new Engineering Building. While it is not intended specially for students, nevertheless they ought to be interested in it, because it treats of a question of vital interest to all members of the engineering profession, both present and prospective.

Editors.

THE PRESENT STATUS OF THE ENGINEERING PROFESSION AND HOW IT MAY BE IMPROVED.

By

Dr. J. A. L. Waddell.

While engineering is certainly the oldest of all the professions, in that it dates back to the time when prehistoric man first performed his simple constructions in stone and timber, it is really the youngest of the so-called learned professions. In fact, it is only of late years that it has been admitted into that honorable company. Not more than a generation or two ago it was claimed, even by some engineers, that engineering was not a profession but merely a trade; and, truth to tell, there was some reason in the statement; but today all that is changed, because not only is engineering truly a profession, but it is undoubtedly the greatest and most important of them all, in that the wonderful progress of the world during the last century has been effected mainly by the work of engineers. Where would civilization stand today without railroads, electric power, the telegraph, the telephone, the steam engine, steamboats, irrigation, water-supply, bridges, steel buildings, mines, and many other important necessities and luxuries too numerous to mention? All these have been evolved in the engineer's busy brain and have been developed by his untiring energy.

But because of its youth as a learned profession, engineering in the public mind has not that status which justly is its due; and for the same reason it is materially and unnecessarily hampered in several ways. Among the various handicaps under which it is still laboring may be mentioned the following:

First: Engineers as a class are insufficiently paid, especially for important work.

Second: The engineer on any construction is not as well protected by law, in regard to his compensation, as is either the workman or the furnisher of materials.

Third: There is no established written code of engineering ethics to govern the members of the profession in their relations with each other and with the public. It is true that there is an unwritten code, but it is far from being effective.

Fourth: The engineering profession is not properly respected by the general public.

In regard to the first complaint, viz., that engineers are insufficiently paid—that is mainly through their own fault. In this particular they are not as well off as masons, bricklayers, or even common laborers, all of whom have organizations to ensure their being properly compensated for their labor. However, there is now being effected in New York City a society termed "The American Institute of Consulting Engineers," whose main object will be to regulate the minimum rates of compensation among independent practitioners for all kinds of engineering services and to determine exactly what expenses should be borne by the client and what by the engineer. Although the "Institute" is undoubtedly governed by selfish motives and may, perhaps, correctly be termed a "union" or "guild," it is, nevertheless, a worthy organization; and, in my opinion, it is destined to effect considerable good, provided that its members will hold together and be governed in their conduct by the rules and regulations which it adopts. As great innovations generally come slowly, it will probably be several years before the influence of the "Institute" begins to be materially felt.

As for the second complaint, it will take much strenuous and concerted effort by a number of the leading engineering societies before the laws of the country can be so changed as efficiently to protect engineers against the dishonest practices of unscrupulous employers. The laborers and furnishers of materials for any construction are protected in respect to their compensation by their ability to place liens upon the work; but the engineer is not. Whenever a company engaged in construction gets into financial difficulties, the first man on the job to have his pay withheld is the engineer, and he is generally the last under such circumstances to receive his compensation—in fact, often he fails ever to get it. This is because he recognizes only too well the law's delays and the expense of litigation, and that generally, after the other employees' accounts are settled, there is nothing left with which to pay him.

Concerning the third complaint, viz., lack of a code of ethics, the speaker has a right to consider himself an authority upon the evil effects thereof; for a large portion of the work of his partner and himself is the protecting of the firm's interests against the attacks of unscrupulous contractors and engineers.

Over and over again, in his career, has he been forced temporarily to lay aside the actual work of planning important structures which had been awarded to him (the finalities of contracts not having been completed) in order to meet the opposition of brother engineers and to frustrate attempts on their part to take away such contracts and secure them for themselves.

That the public should fail to recognize the high position of the Engineer and his consequent rights and dues is deeply to be regretted; but that his co-workers in the profession should fall so far short of the true measure of nobility is a matter of much greater importance. The former condition may be due to ignorance, and therefore excusable; but the latter is a flagrant violation not merely of professional ethics, but of the common justice and fair play which should always govern between man and man.

This is a condition and not a theory which confronts us; and it must be met by engineers in a noble, manly, and generous spirit, each resolving within himself to devote his influence and energy to the advancement of mankind in general and the profession and his fellow members thereof in particular by all means in his power, and never to be found in that body of carping critics, back biters, and unscrupulous antagonists whose sole effort is to pull down and destroy the works, reputations, or characters of those who have been successful in their practice or who are endeavoring to do what is right and just in thought, word, and deed.

The carrying forward of any code of ethics is mainly an individual matter, and the responsibility for its success lies with each engineer. Therefore let each one decide for himself that no possible gain of reputation or riches is great enough to bias or prejudice him in regard to the rights of anyone, and especially of a brother engineer.

Not until such a rule of conduct becomes general and firmly established among engineers, will the public grant to the profession the recognition which is due to it because of the importance of the work which its members perform.

During the last two years there has been on the *tapis* an endeavor to form a professional association of the highest order with the object of correcting all the evils from which engineering is suffering and to make it a real power in the land. Unfortunately, the organization is not yet quite perfected, consequently I do not feel at liberty to mention to-day its title nor the names of its principal promoters who have been chosen from the leading American engineers in all divisions of the profession. However, I am permitted to speak to you of its scope and objects; and ere long these will be made known to the public through the technical press.

Quoting from the proposed constitution, "Its objects shall be: To dignify and exalt the profession of engineer in the broad sense, and to place it upon the highest plane amongst the liberal professions; to bring the different branches of the engineering profession into closer touch and harmony with each other; to bring American and foreign engineers into closer relations with each other; and to secure for the engineering

profession as a whole the recognition commensurate with the importance of its services to the world.

"It will strive to accomplish these objects by all proper, honorable, and legitimate ways and means; by fostering, stimulating, and encouraging the growth and development of the highest professional spirit, ideals, and ethics uniformly in all branches of engineering; by promoting a better understanding and sympathy between these different branches; by advocating more homogeneous and consistent rules and precepts for their guidance in their relations with each other and with the rest of the world; by working for general co-operation and solidarity; by fostering an *esprit de corps* in the profession as a whole; by doing all in its power to elevate the standard and promote the interests of the profession; and by urging its claims, or those of its more distinguished and eminent votaries, to due and proper consideration for public or private honor or recognition."

That great results can confidently be expected from the work of this proposed organization may be concluded from the type of men chosen and still to be chosen for membership and from the interest in the movement thus far shown. To give you some conception of the class of men who will belong to this association, the following further quotation is made from the proposed constitution:

"The qualifications of a candidate for Member shall include the following requirements:

"He must be a citizen of the United States of America.

"He must be at least forty years of age.

"He must have a degree from a University or Technical School of recognized standing.

"He must have a reading knowledge of at least one European language, or else of Esperanto, besides the English language.

"He must be a member, in good standing, of the highest grade, in at least one national engineering or technical society in the United States of America.

"He must have practiced or else taught engineering, or some cognate branch of technology (such as chemistry) continuously for a period of not less than fifteen years, and he must be still engaged actively in practicing or teaching or both.

"He must have been in responsible charge of engineering or technical work or design for a period of not less than five years. If teaching, he must have been in charge of a department in a school of recognized standing for a period of not less than ten years.

(In the case of candidates who have taught and practiced at different portions of their careers, two years of teaching shall be considered the equivalent of one year of engineering practice.)

"He must have been identified with work of importance either by reason of its magnitude or else because of its novel or special character; and it must be shown that he has made a satisfactory record and has obtained a good standing in his branch of the profession through his technical work.

(In the case of a teacher of engineering or of technology, the publication of original books relative to his branch or branches of the profession shall be taken as the equivalent of engineering work.)

"He must be the author of at least one important original publication on some subject or topic related to at least one branch of engineering.

"He must have a personal as well as professional record, reputation, and standing entitling him to the highest consideration as a professional gentleman who is devoted to the progress and advancement of the engineering profession and who is interested in promoting the welfare and sustaining the dignity of that profession.

"In general, the intellectual status of the candidate, and the personal traits or qualities making him a credit and an ornament to the profession of engineering, and, especially, his zeal and devotion to that profession, shall be the paramount considerations in determining his fitness. His financial status shall be of no consideration whatever.

"Any of the foregoing requirements may be waived in any particular case in behalf of a candidate otherwise very desirable; but the said waiver shall be only by the unanimous vote of the Board of Directors."

Two of the preceding clauses quoted from the constitution set forth clearly and concisely the main objects of the proposed association; but there are many minor or subsidiary objects, which were mentioned in an address of mine delivered at the first meeting, from which address permit me to quote, with a few slight and at present unavoidable alterations, as follows:

"The augmenting of individual effort among engineers of all classes by setting before them in membership in this organization a goal to attain and a distinction well worth striving for.

"Such a result is the inevitable sequence of the materialization of our project—and it will come at once, without delay.

"The establishment of a court of last appeal in all matters relating to the profession.

"While our association, of course, could not properly suggest its services in this direction, the call will assuredly come; but it will take time to establish the organization as the natural means of settling disputed professional matters.

"The influencing of legislation, both state and national to promote the development of the profession and to take action in worthy enterprises which involve engineering.

"If our association were to give its formal endorsement to any proposed measure, such approval would carry great weight in securing legislation; but extreme caution would have to be exercised in all cases in order to avoid endorsing projects of doubtful utility and those of a chimerical nature.

"The choosing of engineers for special services, both public and private.

"Here again our association could never legitimately take the initiative, but it would soon become customary, among those needing expert services and not knowing how best to secure them, to appeal thereto for advice. Such advice should invariably be given after due deliberation; and all decisions should be absolutely unbiased by personal leanings. Those most fit for the work contemplated should always be chosen; and where several names are recommended for the same position, it should be made clear whether all are considered to be of equal fitness or else what is the gradation.

"The extending of American engineering influence abroad, especially to the Latin-American republics.

"This object is one of exceeding importance, not merely to the engineering profession in the United States, but also to the Nation, for with the engineers will undoubtedly go trade.

"The inauguration of a code of ethics for engineers in general.

"No engineering society has yet been strong enough to establish such a code, but our association in time could succeed where other organizations have failed. It is an object well worth striving for, although certainly difficult of accomplishment.

"The exchanging of ideas with engineers of foreign countries.

"This could be done best through the honorary members, who should be encouraged to send yearly statements of the progress of engineering in general that has been effected in their respective countries during the past twelve months. One honorary member in each country represented should be appointed as a committee to report thus.

"Increase of compensation for engineers.

"Although at first thought this might seem a rather sordid object for our association to foster, it is really not so; because by increasing

the value of engineers' services the public is impressed with the importance of the profession. In my opinion, we should employ every legitimate means to further this object.

"Improvement in engineering literature.

"By bringing into closer touch the practicing engineers and the professors of engineering and by encouraging them to work together on engineering literature, great improvements in its quality and scope could be effected.

"Encouraging of original research.

"Our association by giving its endorsement to any proposed investigation of a praiseworthy nature could aid greatly in securing the necessary financial aid therefor, either from Governmental or private sources.

"Establishment of testing apparatus.

"An endorsement by our association of any proposed apparatus for testing any of the materials used in engineering would be of service in securing the requisite funds for its construction.

"Many improvements, reforms, and innovations would naturally be brought about through papers presented to the association; and in fact such presentation would be the most logical procedure to secure action on anything of the kind. To show you that there are numerous proper subjects for such papers, permit me to suggest the following topics:

"1. The Study of Foreign Languages in American Technical Institutions.

2. The Ethics of Engineering.

3. Latin-America as a Field for American Engineers.

4. China, ditto.

5. Africa, ditto.

6. How to bring American Engineers into Closer Relations with those of Foreign Countries.

7. How to Bring American Engineers of the Various Groups into Closer Relations with Each Other.

8. How to Avoid the Possibility of Disaster to all Great Public or Private Constructions.

9. Engineering Fees.

10. The Best Technical Books for Engineers in the Various Specialties. (This would be a series of papers or a combined paper by a specially appointed committee representing the various specialties in engineering.)

11. How Best to Enhance the Dignity of the Engineering Profession in the Minds of the General Public.

12. How to Improve Future Engineering Literature.

13. Engineering Degrees.

14. Expert Engineering Evidence in Courts of Law.

15. Punishment for Unprofessional Conduct.

16. Post Graduate Schools for Engineers.

17. How Best to Encourage Original Research in Engineering.

18. The Necessity for Great Testing Machines and Engineering Research Facilities, and How to Procure Them.

19. How to Improve the Methods of Inspection in the Manufacture of Steel Construction.

20. What Should be Done to Develop American Ship-building?

21. Suggestions as to the Best Manner of Developing the Possible Water Powers of the United States.

22. The Advisability of Improving and Developing the Great Waterways of the United States.

23. Sea-Level *versus* Locks for the Panama Canal.

24. How Best to Develop the Resources of Alaska.

25. How Best to Develop the Resources of the Island Possessions of the United States.

26. Improvement in the Teaching of English in Technical Schools.

27. The Needs in Engineering and Technological Courses of Instruction to Attain their Fullest Development.

28. How Best to Conserve the Supply of American Timber and to Economize in its Use.

29. The Conservation of the Coal Supply of the United States.

30. How to Bring Engineers into Closer Relations with the Pure Scientists.

31. The Extent to which Students in the Various Lines of Engineering Should be Taught Mathematics, and How.

32. How Best to Develop a Proper Enthusiasm for the Profession in Engineering Students and Young Engineers.

33. The Relations Between Engineering and Political Economy.

34. The Relations Between the Engineering Profession and Law.

35. How Best to Control and Limit the Pollution of American Rivers and Streams.

36. Engineering and Sociology.

37. Engineering and Politics.

38. Aesthetics in Engineering Constructions.

39. The Study of True Economy in Engineering Designs.

40. The Relations Between Engineering and Architecture.

41. The Beautification of American Cities.

42. The Preparation of a Dictionary of Technical Terms used in American Engineering and their Equivalents in Various Foreign Languages.

43. How Best to Develop and Control the Irrigation of the Arid Lands of the United States.

44. The Preparation of a History of Engineering, either as a whole or as developed in the United States.

45. Smoke Prevention.

46. Uniform Engineering Terminology for English-Speaking Countries.

47. The Furthering of Legislation Conducive to the Advancement of Engineering and of Public and Private Enterprise.

"This is a pretty long list of subjects, but it might easily have been made still more extensive. Enough topics have been enumerated, however, to show that there will be no dearth of matter to occupy legitimately the attention and energies of the members of our association.

"Some of you may have noticed that many of the topics proposed come under the scope of political economy; and it may be objected that such is not engineers' work, but with that objection I beg emphatically to differ. Political economy is a subject that can be treated only by men of years, learning, and experience; and what body of men can there be found so well developed in these lines as the members of our proposed organization? It is the engineers who make the world move, and who so competent as they to say in what manner it should be made to move? There is, in my opinion, no other class of men so well fitted as engineers to deal with questions involving political economy.

"It would be eminently right and proper for our association to discuss such subjects of great public interest as the Panama Canal, even when unsolicited; because it is the right of every American citizen to have his say about how the money which he helps to furnish for such enterprises shall be spent. An unsolicited opinion from our association on such matters would carry great weight with both the public and the Government."

I trust that you will pardon me for devoting most of the time allotted my address to a discussion of this proposed organization, because I am so deeply interested in the success of the movement, and also because I believe it is destined to do far more for the advancement of the engineering profession than anything that has ever been attempted.

THE ENGINEER'S DUTY AS A CITIZEN.

By

Rear Admiral Geo. W. Melville, U. S. N., Ret.

This paper, which was presented in July, 1910, to the American Society of Mechanical Engineers, is by one of America's most vigorous technical writers; and the elegance of its diction is strikingly apparent. Moreover, it treats of a subject of the utmost importance to the development of the Engineering Profession, consequently it should prove interesting reading for technical students.

Admiral Melville was born in New York City, January 10, 1841, and was educated at the City's public and grammar schools, and at the Brooklyn Polytechnic College. At the same time he learned the machinist trade with James Binns, Esq., of the Brooklyn Machine Works.

In July 1861, he entered the Navy as third assistant engineer with the rank of midshipman. He passed through all the grades in regular rotation until in 1881 he attained the position of Chief Engineer, U. S. N., with the rank of Lieutenant-Commander, in the meantime having served both afloat and ashore in various fleets and squadrons, and having done special duty at the Navy Yards.

Admiral Melville is a noted Arctic explorer. His first Arctic cruise was in the U. S. S. Tigress on what is known as the "Hall Relief Expedition" to Greenland, etc.

His second Arctic expedition was in the Jeannette through Behring Strait. The ship being destroyed by ice, he returned with the ship's company to the mouth of the Lena River, in command of the Whale Boat. The other two boats, commanded by Lieutenant-Commander De-Long and Lieutenant Chipp, U. S. N., were lost. After recruiting his part of the company, he returned to the Arctic Ocean and found and buried all the dead of the other two boats.

His third Arctic expedition was in the Thetis, commanded by Commander Schley, U. S. N., sent to rescue the remainder of the Greely party, which task was effected at Cape Sabine opposite Littleton Island in Davis Strait.

In 1887 he was appointed Chief of the Bureau of Steam Engineering with the rank of Commodore, continuing in that office for sixteen years and retiring at the age of sixty-two with the rank of Rear Admiral-

Senior Grade. Since then he has been conducting an office as Naval Architect and Consulting Engineer at Philadelphia, Pa.

In addition to the preceding, Admiral Melville has received the following distinctions:

The degree of Master of Arts from Stevens Institute of Technology.

The degree of Doctor of Laws from Georgetown University, Va.

The degree of Doctor of Engineering from both the University of Pennsylvania and Columbia College, and

The Military Order of St. Stanislaus of the first class from the Czar of Russia.

Editors.

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By

Rear Admiral Geo. W. Melville, U. S. N., Ret.

Doubtless everyone present has read Macaulay's famous chapter, in his History of England, which describes the conditions obtaining in 1685. This chapter is one of the most wonderful descriptions in all literature, giving as it does the details of every feature of the life of that time, some 200 years ago. I refer to this account because I want you to contrast it with the conditions of today, to which we are so accustomed that it requires some effort to remember that the comfort and conveniences of the poor man of today are beyond the wildest dreams of the wealthiest men of the period described by Macaulay. At that time there were no sidewalks, and the streets were unlighted: the highways became bogs in rainy weather, and highway robbery was almost a recognized profession; sanitation and sewerage were unknown, and refuse heaps accumulated under the windows of the great and the wealthy; it was dangerous to go out alone at night; and it was still legal to hang the unfortunate who stole a loaf of bread.

Macaulay remarks in one place that at such fashionable watering places as Bath, the nobility had to put up with accommodations at which their servants in the year 1850, in which he was writing, would turn up their noses.

Now when we compare the two periods and remember that there is hardly a branch of human activity in which there has not been the greatest improvement, we are naturally led to ask to whom is the improvement due.

In all fairness, we should doubtless have to say that most of the professions have had a part in the amelioration of conditions, although the student of history remembers with regret how the great lawyers opposed the remission of the death penalty for what we would now consider minor offenses.

Physicians are undoubtedly entitled to much credit for advances in medicine, surgery, sanitation, and hygiene; and we might go on and give credit to others. It seems to me, however, that when some future Macaulay describes the condition of the United States at the beginning of the twentieth century and attempts to award the credit for the existing comforts and conveniences, the major part must be given to the

profession of engineering. Within 100 years after the time described by Macaulay, Watt had so far perfected the steam engine as to bring about the beginnings of the factory system, making possible the low cost of clothing and of articles of manufacture of every kind. In a century the steamboat and the railroad had come into being. Then we had gas for illumination and the telegraph for rapid communication, and so on down the line to the present day with its electric light, electric railroad, and telephone, every one due to the engineer.

Added to the superior facilities of communication by railroad and steamer came mechanical refrigeration, which enables the densely populated countries of the old world to be supplied with meats from the great plains of the new, and these superior means of transportation have provided the rapid movement of food products so that the whole world contributes to the delicacies of our table, no matter where we are.

The contrast between the conditions of the great cities of the period described by Macaulay with those of today is startling. Cities were without the conveniences which a country town of moderate size would now consider absolute necessities. The systems of water distribution, sewerage, street paving, etc., are all the work of the engineer, and filtration plants obviously are engineering works, even if we consider their inception to be due to the medical men.

Perhaps you ask why I should go into these details which are common knowledge, when their mention can give little additional information. My reason is that I want to emphasize the facts as a basis for the discussion of the question: What does the engineer owe to society when society owes so much to the engineer?

In the early history of the race, when war was the almost constant condition, it was inevitable that the great warrior should become the leader and ruler of the people. As time went on, the engineer developed, as we know from the wonderful works of antiquity like the great aqueducts, the bridges, tunnels, and roads; but, from the past, had come the tradition lodging leadership in the warrior caste, where it remained for many centuries, and, indeed, has still a tendency to remain in monarchical countries.

During the last century, wars have been less frequent, and, due to the engineer, commerce has become so prominent that while the hereditary nobility still linger on the scene, their titles have become almost meaningless. This was particularly noticeable when one of the English dukes served in the quartermaster's department during the Boer war in a subordinate capacity, and still more so in the war between

Russia and Japan, when only one Russian general was a member of the nobility.

I think you will see the point to which I am leading; namely, that in this "age of the engineer," he should not rest content simply with doing the work which makes for our comfort and happiness, at the command of others (men who are lawyers or simply business men), but that the engineer himself should take a vital and directing part in the administration of affairs. I know the objection that an engineer's professional work is so engrossing and exacting that he cannot become a politician in the sense that a politician is a man who gives all his time to pulling wires and filling offices. This is doubtless true, but where it is a matter of self-interest, the engineer, like other men, can find time for this extra work.

We Americans are fond of claiming that we have the greatest country and the freest and best government in the world. That government, however, for its efficiency and integrity depends upon us as citizens, and it ought to be a matter of the greatest pride to every American to do his part, so far as lies in him, to make the country and its government better and happier every year.

In view of the enormously important part which the engineer plays in the life of today, it is incumbent upon him, more than upon most other men, to take a vital interest in the work of government and to lend his trained ability and judgment to its perfection. I do not mean, of course, that the engineer should do routine professional work for the government without compensation, but that in the discussion of public improvements and the administration of governmental departments, he should take an active public stand to influence and guide the non-expert part of the population.

It is notorious that enormous amounts of money have been squandered on great public works because they were undertaken in a way which every engineer knew must be inefficient and uneconomical. If all of us as engineers had a keen sense of our duty in this respect, and would properly utilize our experience and ability through the daily press, the magazines, and the reviews by public discussion and in the daily intercourse of life, as well as by impressing the truth upon our representatives in municipal and national affairs, I believe we should accomplish an immense amount of good.

It will be understood, I am sure, that in this I refer almost entirely to the relations of engineers to society in general, and not to other professional men. For many years engineers have been most generous in making public to their technical brethren the results of their experience, and our own Proceedings are full of instances. It would be im-

possible to name more than a few, but perhaps the most notable case was that of Past-President Taylor in the publication of the results of his life work of research on the "Art of Cutting Metals."

A problem of foremost importance at the present time is the management of labor to secure efficient work and satisfied men. It is probable that the direction of more than 90 per cent of the skilled labor is in the hands of engineers. Most emphatically is this a case where engineers owe a great duty to society. It is, therefore, an especial pleasure to recognize that some of our own members have played a foremost part in the best work that has been done in devising plans for compensating labor which will stimulate the men to their best efforts and reward them adequately. The names of Halsey, Taylor, Gantt, and Emerson will at once occur to you.

It would be inappropriate in this brief address to attempt a detailed discussion of the labor problem, but I feel that I shall voice the sentiment of every one present when I say that the effort of every patriotic American should be exerted to maintain absolute freedom of contract in labor matters as in all others. Just as we are opposed to monopoly by capital, so we are to the same thing by labor.

No reasonable man objects to labor organizations, as such. They have undoubtedly been the cause of much benefit to the men. The danger with them, as with political organizations, is the formation of a machine which utilizes the organization solely for the selfish interests of the members of the machine. There can be no doubt whatever that many strikes are against the real wishes of the majority of the men, who are overborne by the machine and its adherents; and it is also true that the net result of nearly all strikes is an actual loss to the men. The problem is an exceedingly difficult one and requires the greatest wisdom, patience, and tact for its complete solution; if, indeed, taking human nature as it is, we can ever hope for its removal from the list of worries of the manager of great enterprises.

Many questions prominently before the public are peculiarly such as require engineering knowledge for their proper understanding and regulation. The word trust has come to have such a sinister meaning that it is only necessary to fasten it upon an enterprise to render it criminal in the popular estimation. We have recently heard a great deal about the so-called Water Power Trust, the charge being that all the available power sites were being grabbed so as to subject our citizens at some future time to the payment of tribute for electric power derived from them. I am not concerned, at the moment, with a discussion of monopolies, which we all deprecate, but to point out that engineers know these water powers cannot be made available except by the

expenditure of large sums of money. Indeed, it would be easy to point out the fortunes that have been lost in the attempted exploitation of these supposedly lucrative natural gifts. The general public is utterly misled by statements that these power sites are obtained for nothing, the idea being that the development is a matter of small expense. Here the engineer can do a work of real benefit by disseminating correct information.

Again, in the consideration of public service corporations, the engineer knows the cost of installation and operation, and so can discuss intelligently whether rates are fair or exorbitant, and whether capital represents real investment or water. These are problems of the greatest importance, and for their proper solution, the electorate needs training that can be given by no one else so well as by the engineer.

About a year ago, at our Washington meeting, I did what I could along this line by pointing out mistakes in connection with navy yard organization, and this illustrates very clearly what I am advocating for all engineers. Here was a great department of the Government for which the annual appropriation now exceeds one hundred millions of dollars. Its administration had fallen into the hands of a man who started to make changes in the entire administration which would have been ruinous to efficiency; and yet, hardly a voice was raised in opposition. I even heard of a case where one of our leading engineering journals refused to publish a criticism of this system submitted to them through a man whom they knew and esteemed most highly, but who stated that the author was so situated that he could not permit his name to be used. Not only would the magazine not print the article but they did not take enough interest in this most important subject to study it for themselves and comment upon it.

I do not mean to imply that engineers never show public spirit in such ways as I have suggested: there are too many instances to the contrary. Our own Society and others which have taken part in the movement for conservation of our national resources have set a good example, and other cases could be cited where individual engineers have shown commendable enthusiasm. These, however, are mostly cases of unusual importance and relatively infrequent. What I am pleading for is a habit of mind that will cause engineers to take an active part in all public questions, great or small, where their knowledge and experience will enable them to contribute to the common good.

The movement which has been set on foot by Congress to establish a Bureau of Mines suggests an opportunity for the engineer to take an active part in public affairs. I question whether this idea might not be developed a little further by providing for a department

with a Cabinet officer at the head, to be called the Department of Mines and Manufactures, with the scope implied by the title[1].

When we think of the enormous values represented by the industries which would come within the purview of such a department, it seems only reasonable that they should be under the care of a Cabinet officer. If we are told that there is already the Bureau of Corporations, I would point out that the object of this proposed new department is quite different from that of the existing bureau which thus far, in the estimation of many, has done little or nothing to advance the interests of manufacturing, but has, in their opinion, disclosed a spirit which is almost inimical. The department that I have in mind would aim to stimulate improvement and progress in manufacturers and industries generally, in somewhat the same way that the Department of Agriculture has done for the farmers.

We have often heard engineers complain that the profession did not receive due praise and credit for its splendid work. This is true enough, but is the reason not very largely because the engineer hitherto has been content to do the work and then fade into the background, leaving the talking and the management to the lawyer and the politician? With the advance of technical education, engineers are more and more becoming the high officials of our large corporations: It is to these men, whose talents and trained ability have made them the leaders in manufacturing and in business, that the country has the right to look for leaders in the affairs of government, and not until the engineer of all grades has done his part towards the promotion of the highest efficiency of the Government can he truly say that he is, in the fullest sense of the term, a good citizen of the Republic.

1. This address was prepared more than a month ago, and since that time the bill in Congress referred to above has become a law. The newspapers have published an item that consideration was being given to the formation of a Department of Public Works. This is along the same general lines as my suggestion above for a Cabinet officer to head a department of Mines and Manufactures.

THE POINT OF VIEW.

By

Walter C. Kerr, M. E.

This address, which was delivered to the graduating class of Stevens Institute of Technology on June 16, 1904, and the two following addresses are from the pen of one of America's most prominent mechanical engineers, whose early death a short time since was a severe loss to the engineering profession. Mr. Kerr was a member of the well known engineering firm of Westinghouse, Church, Kerr, and Company, which has engineered so many great enterprises in this and other countries. As can be seen by his writings, Mr. Kerr was a man who was truly interested in the development of the engineering profession, and especially in the welfare of its student members.

The teachings of this paper are so sound that every student of engineering should familiarize himself with them and apply them in his work as both student and engineer.

Walter Craig Kerr was born at St. Peter, Minn., Nov. 8, 1858, and received his early education in the common schools at that place. In 1879 he was graduated from Cornell University with the degree of B. M. E., then he taught in that institution for three years, first as instructor and then as Assistant Professor. In 1883 he entered the employ of the Westinghouse Machine Company as salesman; and a year later he helped to organize Westinghouse, Church, Kerr and Company, first holding the office of treasurer, then that of vice president, and, finally, that of president.

From an article written shortly after his death for the Electrical Journal, we quote the following:

"In about the middle nineties, Mr. Kerr began to formulate his ideas of engineering service. He foresaw the approaching era of vast public improvements which would call for the creation of great utilities involving many branches of engineering knowledge. He felt that such projects would have to be handled in their entirety, from contemplation to execution, without artificial divisions to harbor hazard and prevent a true correlation of these many branches into a harmonious whole. He believed strongly that the performance of such work should be carried on in the unselfish spirit of engineering service, unhampered by any idea of speculative gain, the compensation to be small but certain, and that there should be absolute community of interest between property owner and property creator. It was the master and servant principle

a priori, under which large and difficult work could be handled by a simple and effective relationship. It was the characteristic of the man, plain and true himself, to see the full application of a plain principle.

"His genius for organization now came into play, and he began the work which chiefly marked his life success. His whole conception of engineering work was founded on organized, co-operative effort. He believed in individuality; no man ever did more to encourage it. He had a way of giving to a subordinate authority and responsibility in such measure that one soon rose to his fullest powers. But he understood, too, the limitations of the one man. He felt there were some men of but ordinary capacity, who on their own resource performing with small success, might in an organization contribute much good. He also held strong views respecting certain other men who had worked alone successfully, and sometimes brilliantly, but were by temperament and habit wholly unfitted for co-operative effort. He had an unerring sense of fitting men together. He believed that they should be selected with care, then taken as they were, without trying to remake them, but rather to develop what they had to the fullest use. He reposed great confidence in his men. He respected them in a manner to compel their own fullest self-respect. There never could be in any organization of men a greater absence of personal differences than existed in the atmosphere of Mr. Kerr's leadership. He was in the highest degree an organization man, around whom men worked with an *esprit de corps* and mutuality of purpose which only a real organizer could inspire. Such an organization was indeed essential to the success of his theory. It was necessarily of slow growth, and required to be a large aggregation of engineers variously specialized in different branches of work, as well as architects, chemists, and statistical experts; in fact, all the organized talent which could handle any work from beginning to end.

"We sometimes think that business and sentiment are wide apart. In point of fact, business is a human relationship; and if the judgment of men had always been divorced from their emotions, many of their great material successes had never been achieved. Mr. Kerr was proud of his organization—not only that it prospered materially, but that it stood for correct methods of doing work. He was able to see the fruition of his ideas in work done. Great undertakings, totaling vast sums of money, have been accomplished by his methods. It is the only large engineering organization today which by its engineering work alone, without financing departments or property-controlling adjuncts, has thriven and grown. He may well be regarded as the leading constructive engineer of his time."

Editors.

THE POINT OF VIEW.

By

Walter C. Kerr, M. E.

It is a pleasure to talk to a lot of young men who are about to become engineers. It was not so long ago that I came to your age less well prepared, perhaps, then any of you. When I look back at the engineering education through which men of my time were launched, and then consider the training you have had and the opportunities before you, I have reason to wonder why I am here.

I hesitate to advise you. You have already had so much advice that I do not know whether you can hold more. What I can say in a few minutes will amount to little, hence let me use these minutes to suggest that you advise yourselves along certain lines which I will propose by way of point of view. If you look straight you will see straight. You cannot think wrong and act right. Your perspective will be distorted if you haven't the right point of view.

You are leaving a good institution for a good world. Your Alma Mater has built up around you excellent facilities for giving you what you need, and other institutions have likewise cared for their own.

The so-called liberal education has always been highly academic. Trade school engineering has been strictly non-academic. The two have joined hands fortuitously in our modern institutions. The liberal education has become less and the technical more academic, with advantage to both. There is, however, danger of engineering education growing too academic, for several reasons: One is the disposition to include in technical training a liberal education, which of itself is not undesirable. Another is that engineering professors often lean unduly towards academic views and processes, and thus lose touch with the spirit of the engineering world. Greater than either of these is the tendency of all things to move in the line of least resistance; and all learning which depends upon the intellect alone is more easily acquired than that which depends upon other sources. The proof of this need go no further than to remember that no literature is finer than that written two thousand years ago; no philosophy has fundamentally improved upon that of the ancients; the highest flights of intellect and mathematics were reached during the ages in which the world was observed to be composed of four elements—earth, air, fire, and water.

A review of knowledge shows the great preponderance of the intellectual over the material, and it is only within late centuries, in fact almost the past century, that the human mind has seemed capable of turning from the lesser resistance of intellectual attainment to the greater capacity for physical observation and comprehension. We have but recently come to the era of intense mental operations, dealing with laws and principles which require insight greater than the intellect can grasp unless aided by the senses. Contrary, therefore, to common belief, I assert that the highest refinement of knowledge follows from the highest use of the senses; and that it has taken thousands of years of pure intellectual development to attain a state in which the powers of nature can, through the human intellect, be made useful to mankind and add largely to knowledge. Do not, therefore, get a wrong view of the faculties involved in science, in the application of the laws of nature, applied mechanics, and the powers of comprehension which underlie engineering. There is still room for doubt—not debatable here—as to what constitutes liberal education.

I hope for the time when the spirit of engineering as found in practice will form a more definite part of engineering education. This, I think, must come through the professor keeping in close practical touch with the engineering world. There are various ways in which this may be accomplished, but I know of none better than by each professor doing a reasonable amount of practical work for commercial purposes. Under some conditions, this may be consistently accomplished during a portion of his time, but I am inclined to think that eventually our professors will devote all their time to instruction while they teach and go periodically into the world, a few years at a time, for practice. Thus the professorial life would not be so exclusively educational, and our growing engineering institutions may be enabled to enlarge their faculties by the devotion to teaching of a portion of the time of men who are primarily engaged in commercial work.

Now that you have your so-called education, what are you going to do with it? I cannot tell you, but I can suggest some points of view.

Begin by forgetting yourself. All thought of self is some form of selfishness, and selfishness never produced anything better than more selfishness. It often breeds something worse. Genius is all right in its way, but it will not do your work. Get a right idea of work. Remember that time is the essence of most things, and is not inconsistent with thoroughness.

We hear much about opportunities. They are everywhere plentiful. Remember that your opportunity is the little one that lies squarely in front of you, not the large one which you hope to find further along.

Many a man is surrounded with opportunities who never seizes one. There are traditions that Adam, William Tell, and Sir Isaac Newton each had an affair with an apple, but with different results.

Your first duty is always to that which lies across your path. The only step which you can take in advance is the next one. This leads to a simplicity of action which is commendable. Don't ramble.

The refinement of thought which is apt to follow high training often leads the mind to overlook simplicity and even to seek complexity. The wealth of modern appliances tends likewise; and it is thus easy to acquire that over-refinement, often termed theoretical, as against the simplicity which is called practical.

From one point of view all graduates can be divided into two classes: those who think their knowledge is a little long for their opportunities; and, those who think almost anything is a little long for their knowledge. Both are apt to think that the knowledge they have acquired will become the essence of performance. You will soon find that knowledge hasn't much to do with effectiveness. It is necessary, only as words are essential to the expression of thought. You will find knowledge a good tool, but not the vital force with which you perform. You will fall back upon human effort and action, and find that it is the human-engine and not the knowledge-engine that does the work.

Cultivate singleness of purpose. This is more important than you may think. It is intuitive with the comparatively ignorant, and often absent in the highly trained. We are frequently surprised at the great competency of the ignorant contractor or foreman, on whom judgment is often passed by saying that he is a practical man and gets results. Analysis will show that his best quality is singleness of purpose, which leads him to do vigorously the one thing before him, without distraction following from knowing or thinking about too many other things. The broadening power of education and training increases the range of contemplation, but unless the power of concentration is cultivated, there follows a tendency to scatter instead of to acquire that singleness of purpose which leads to effective action. David Starr Jordan has said: "The purpose of knowledge is action. But to refuse action is to secure time for the acquisition of more knowledge. It is written in the very structure of the brain that each impression of the senses must bring with it the impulse to act. To resist this impulse is to destroy it. * * * * This lack of balance between knowledge and achievement is the main element in a form of ineffectiveness which, with various others, has been uncritically called degeneration." Thus President Jordan shows how even much more than a little knowledge may be a dangerous thing. The highly-trained man, therefore, needs, as a complement to his train-

ing, unusual powers of concentration, in order that the virtue of singleness of purpose may not be lost. This faculty a man must have or acquire himself. It is not in the books. It cannot be taught. It can only be suggested by precept and example.

From directness of purpose naturally follows diligence in getting what you go after, and not being easily turned aside by resistance. When you are getting what you go after, get it all. Avoid the mediocrity of compromise. Be thorough and stand for full competency in everything, from main essentials to details. Just so far as education, assisted by concentration, contributes to singleness of purpose it is useful, but where by length, breadth, or depth it dilutes human effort, it lacks value. It is, therefore, not so much the question how much educational training you have as it is how you use it. Some can use a little with great effect, because their point of view is right; others scatter so badly that they cannot use their knowledge at all; while some distorted minds seem to have a faculty for misapplying a large amount of acquired knowledge through complicated processes full of error. To be right, you must be 100 per cent. right. Charity may pardon human nature its percentage of delinquency but this is a human matter. The laws of nature, mathematics, and engineering do not pardon anything. The man may, therefore, be absolved from censure, but his work must stand the rigid test of inviolable law. Nor is it too much to say that you must be right the first time. Much of our engineering is only done once, and it must be done right that once. A man who has learned by experience to do a thing deserves no credit for doing it right. He is then only a repeating machine. Real power is characterized by ability to perform right the first time that which a man never did before. Such performance involves the power to assimilate and adapt experiences, of more or less like or unlike kind, in a way to bring forth correct results. This is the true use of experience, wherein a man is a thinking, active power, and not a mere repeater.

Clearness of thought is an essential often lacking. This, too, follows from concentration and singleness of purpose. Many minds confuse themselves with a wealth of ideas, grading from the well formed to hazy, indistinct conceptions. You can clear your mind by proper habits of thought. Train yourself to separate essentials and non-essentials and confine your consideration to the essentials, to distinguish between what you know and what you only vaguely surmise, clearly eliminating opinion from facts. Nothing is more helpful than conference with yourself, in which you determine what you think of your own thoughts. This is aided by the moderate cultivation of system—thinking in an orderly manner, beginning at the beginning, end-

ing at the end, and being sure to have a middle. With this there should be no slavery to system, but let each find his own logical way.

Besides what are commonly known as ideas, men have intuitions—sometimes called impressions or opinions—which they cannot readily prove. These, I believe, are identical with reason, except that while reason is composed of a sequence of distinct ideas, each capable of expression, intuitions follow from the capacity of the human mind to integrate small ideas and impressions, each of which is too small to stand alone, or to be readily expressed, but which integrated form a concrete mental impression, called an intuition, and which is of exactly the same character as reason, except that it is composed of smaller and almost intangible units. Do not, therefore, discard intuitions as inferior to reason. Analysis will sometimes develop intuition into an expressible, logical thought.

You have all had ideas and you will have more of them. Some ideas seem bigger than others. These mental forces, like other forces, only do work when in motion. Hence your ideas are only valuable when put into execution, and this often requires more talent than to originate them. Some men seem to consider their ideas so good that they will execute themselves.

A point of view is involved in the power to rationalize. This again is a thing which each man does for himself in his own best way, and its essence consists in asking one's self whether the thing is reasonable. It is a great check upon error. It applies equally to nearly everything of which engineering is composed. It is the power of the human mind, after performing in more or less systematic and conventional ways, to stand off and look at results and ask one's self whether they are reasonable. One man will figure that certain material weighs two hundred tons, and believe it. Another will say that there is something wrong in that, for it all came on two cars.

Every young man comes sooner or later upon a dilemma, in which he is more or less drawn in opposite directions by his confidence on the one hand and timidity on the other; a desire to perform backed by the courage of his convictions, but on the other hand resisted by his inability to see his way through in orderly progression to a desired end. This is about the time to show your nerve. Don't be dazed and baffled, but make a start. Use your wits and you will get somewhere, and if you cannot always see the end, it will constantly get nearer and plainer when you go as far as you can see and then see how far you can go.

Another point of view concerns engineering expression. This may be through designs, drawings, mathematical determinations, or words, and finally by work done. The lamest of these is words. All engineer-

ing is so non-literary in character that the use of language is too much neglected, leading to expressions that do not properly convey thought. In engineering, it is not rhetoric but diction that makes expression clear, and diction is best learned from the dictionary. It is well for a young engineer to cultivate his vocabulary, and learn to use words in their right sense. They are then usually understood, even by those who have less knowledge. A word of caution, however, against assuming that a lack of facility of expression can cloak an absence of knowing what you think. Engineering documents, specifications, and letters are full of mis-statements due to the careless use of language. Conciseness cannot be over-estimated. Brevity is desirable, but not at the expense of clearness. Conversely, a certain degree of facility should be acquired in reading the words of others. Some seem incapable of understanding plain language when spoken or written. Anyone persistently failing to understand the language of others has limitations needing correction.

One of the worst attributes in engineering, and which is fundamentally born of conceit, is the tendency to fasten error, censure, and responsibility on others. There are times when a man needs to stand himself up in front of himself and ask: What is the matter with me? The capacity of any man to admit his own error and frailty of judgment is a measure of strength rather than weakness.

Perhaps no personal attributes are of greater importance in the conduct of the business affairs of an engineering life than good cheer and non-contentiousness—not only because these are right and agreeable, but because they enable a man to work better and to be better understood, and because they add weight to his opinions. There is a certain reasonable optimism of manner which makes a man and his ideas welcome, even though they must of necessity sometimes be critical. To vote aye and believe that things can be done makes a man helpful to others and to enterprises. Discontent is not a sign of progression.

Each of you probably has a preconceived notion of following some line of engineering. Be careful about your self-analysis. The field is large and has room for all of the various types of men, some of whom incline to constructive operations, others toward inventive, some to the contemplative. Again, within all these divisions, some tend toward professional and others toward trade work. No one can advise what is best for you. This you must find out for yourself. I cannot help, however, a certain predilection in favor of a young man being just an engineer, and not any particular kind of an engineer—not specializing while too young, but developing along versatile lines,

ready to turn his hand equally well to any task within his general scope. In this, there is a good deal in the point of view, and the man who believes he can apply himself in one direction about as well as another will come nearer doing it than one who thinks he cannot.

When you start your practical work, you will doubtless try to improve things. That is a legitimate purpose, if not overworked. I am not going to attempt to tell you what needs improvement, but the one improvement that most things need is in the line of sufficiency. You can think this over for yourself and apply it where it fits.

There is another point of view seldom considered. It relates to environment and the power to vary. It is pertinent to engineering. Man ascended through and exists under the laws of an organic evolution, which occurred almost entirely in early geological ages, under water, within a few miles of shore, under substantially constant temperature, constant pressure, and uniform food supply, and thus in about the simplest possible environment. It was caused, primarily, through the force known as the power to vary; and the reason that evolution spanned the space from the simple cell to the vertebrate animal in so short a time was that this power was not resisted by complex environment. When organisms emerged from the water to the more complex environment of the land, and as environment grew constantly more intricate, its resistance retarded evolution and resulted in fixation of species until ordinal evolution practically ceased. It is the complexity of the environment of the world that presses upon you and tries to hold you back from the exercise of your native power to vary. A good environment is certainly less harmfully resistant than a bad one, but remember that environment is not a force. It is not a producer. You are the producer. Whatever your power to vary, environment will only resist and reduce it.

Therefore, remember that all the good you accomplish is going to come out of yourself. You cannot borrow it, and you cannot make it out of that which has been poured into you by education or otherwise. All that you receive is only a certain quantity of knowledge, acquired by education, experience, or other training, which will have a certain influence upon what comes out of yourself as your own. It is the inherent capacity to perform with your own brain which will make you what you become, and not the mere transmission of that which you have acquired. Your knowledge, therefore, is of little avail until you make it inherently a part of yourself through mental assimilation and utilization. The clearer you comprehend these things, the more readily you can make use of them as against the process of mere acquirement with a vague motive that in some way or other what you acquire may

be of benefit or that environment will be the force that makes your talent effective. Some have gone through experience without acquiring it; and many a man who has received an education has not *got* any, because he allowed it to be a thing apart from his personality—and it slipped away.

KNOWLEDGE AND ACTION.

By

Walter C. Kerr, M. E.

This address was delivered on June 8, 1906, to the graduating class of Staten Island Academy. It gives in very condensed form much sensible advice to young men, and is conspicuous for the wisdom of the author's statements, reasoning, and conclusions. His utterances are well worthy the attention of every thinking man, young or old, technical or non-technical.

Editors.

KNOWLEDGE AND ACTION.

By

Walter C. Kerr, M. E.

Some days come so seldom that they become occasions of special mark. The day of graduation is one. It sometimes seems as if young people come to halls of learning with little, and in a few years take away much. This is not quite what happens. You come with much or little as the case may be and you take away just what you brought, except for the pruning, training, and straightening out which your natural possessions have undergone by the process known as education. Meanwhile, you have acquired some facts and these are, of course, an added measure to what you formerly had. Many of these you will unfortunately forget, but do not think that they have not done you good while they stayed with you, nor that their effect is measured only by their endurance.

The only objection I have to commencements, whether of academies or colleges, is the intimation that they are the end of education and the beginning of the world. Education is a continuous performance, the first acts of which are within halls where systematic guiding gives direction and method to personal endeavor. One reason why many who have had much schooling are poorly educated is that they stopped learning, and by a strange anomaly they seemed to stop at commencement.

The education you get through books and teachers is elementary. That which you gain yourself may be profound. Profundity is wholly a matter of quality, not quantity. The world is too full of a number of things, and you will find more tendency to scatter than to concentrate. It is, therefore, well to do whatever you do with all your might and regard nothing as too small to be done the best you know how. Cleverness will not accomplish much. Brilliancy only serves permanently to polish good things and temporarily to polish bad ones. Grace and culture lend charm to anything, but none of these things make for progress. Advancement only comes through good hard work, diligent application, faithful performance, correctness, accuracy, and that fine display of judgment which flows only from a well ordered mind, capable of thinking independently, acting resolutely, and fearing nothing.

At this commencement time it is well to commence to forget the standards set by the completion of printed pages and the measure fixed by examinations. The world's problems do not come systematically and in the preferred order of easy ones first, followed by a gradation of the most difficult. They come by chance and they hit you endwise, sideways, and with all degrees of percussion. You must meet them, solve them, get good out of them, and utilize them as the means to further achievement.

Some persons devote much time to passing opinions stating what they think. It does not make much difference what you think about things. It is what you do about them. There is even danger of thinking too much unless thought is intuitively coupled with action. Your thoughts may sometimes wander harmlessly, but your acts need be right all the time. If you can now begin with the elementary education you have received in a good academy, or even the more extended but still elementary education which some of you will receive in college, you can proceed to make your personality effective in doing those things which your natural tendencies lead you to do best. You will then, in the course of perhaps twenty or more years, become fairly educated as measured by the standard of human performance related to the average span of life.

Humanity is composed of all kinds of people possessing widely different temperaments, tastes, and abilities. It is well they are not all alike. Anyone will achieve the greatest effectiveness through the opportunities and training which develop native powers. Any other training is liable to stunt the natural growth. Variation in progressive development should be in the direction in which one tends to vary. This assists in the survival of the fittest, the survival of the unlike, the survival of the effective.

Manifestly there must be as many kinds of education as there are types of people, and fortunately the number is not so great but that they can be readily supplied, at least within our higher institutions. So long as education was confined to one channel, those whom the channel precisely fitted were greatly benefited; those whom the channel somewhat fitted were somewhat benefited; those to whom the channel was a misfit were injured, because during the formative period of their development their native power to vary was resisted, their minds forced away from their natural trend, and energies which could have been potent for good in certain directions were dwarfed by the compulsory exertion of uninteresting, unproductive effort. This results in a kind of mediocrity which is stagnation. You can't make anything good of a

man except to make him better in that which he is. You can't unmake him and make him over again.

If it be held that one must needs have the so-called liberal education in order to be well rounded, it is pertinent first to determine whether roundness is what is really wanted and the fitness of the subject to the end. We don't build walls of round stones. We hew them square —some are better rough hewn and others are better when polished. It is not well to attempt to take all the corners off humanity. They should be left on to dent something.

When it is observed that in our modern universities which offer to students wide ranges of educational courses, less than one-quarter follow classical pursuits when left to free choice, and that over three-quarters elect professional and industrial education, there is good reason to believe that this is about the proportion in which minds are fitted to receive benefit from the acquirement of the respective classes of knowledge and training. I, therefore, maintain that instead of decadence in the humanities they are elevated by this natural selection, because their representatives become only those whose minds are fitted to take such education and who will, therefore, conspicuously represent the best possibilities of classical training applied to those to whom it is adapted.

In addition to the several agreeable and desirable attributes of classical training, its fundamental benefit comes through the melting down and recasting of thought, which to some minds is a stimulating and cultivating process. There are other processes of like kind and quality that are adapted to other minds, notably the melting down of the laws of nature and recasting them as applied science. Another cultivating and most useful process, too little practiced, is the melting down of one's own thoughts and so recasting them that they can be understood.

We have heard too much about knowledge for its own sake versus knowledge for use. All knowledge is for use. All education is for action. The engineer uses mechanics and thermo-dynamics in a certain direct way. The architect uses art and constructive knowledge in a similar way. The lawyer uses his knowledge in a less material way. The classical or philosophical man uses his acquirements in a different way, but if he does not use them they are useless. The older I grow the more I think there is no such thing as liberal education, liberal arts, or liberal anything, as distinct from specialized departments of knowledge. As to the so-called specialized courses, these are only names. They are no more special than the humanities. Some are scarcely so highly specialized. All education is liberal or all is technical, according to our definitions, but all is for use.

We hear too much about standards. They are all right in their way, if they do not tend to crystallize error. What we want are best methods. They can never become quite fixed, but must always be getting better in order to be the best. They must be effective and efficient rather than old or new. Precedent has no inherent merit. Only merit has merit. Times, conditions, and arts change so rapidly that the presumption is against rather than for the older methods.

One must have the reserve power to do more than conventional duties, to double or treble the pace when necessary; but there should be no wasting of energy by trying to do it all the time. In large organizations, men of fair attainments but who have shown no surplus capacity are dropped to make room for others who may be more available in time of emergency.

There are many who would rather rest on an excuse than find a way. Too many find reasons for not doing things. As Grant once said regarding the first requisite of a general, he must love to fight, because there are always as many reasons for not fighting as for fighting, and one must fight to win. So you must prefer to do things and not be content with reasons why you can't.

To youth this old world is always a new country. Pioneers must plunge in, turn over what to them is new soil, and make of it the best they can, always in the spirit of industry and honesty, with that aspiration for betterment which invariably turns for good that which is worthy and turns to naught that which is undesirable. Thus you plunge, step, or wander into a new world; and the impetus with which you enter it is a factor in the *vis viva* with which you will carry through. Repose has its virtues, but you will always find it easier to slow down than to speed up.

One-half of all human performance is composed of perception, and the other half is acting upon what you perceive. Never mind the formula. Go straight for what you see and you will always find your duty right in front of you. Stay by it until it is done. Do it simply and you will do it easily and well. Never mind your knowledge. It isn't your power. It is only a tool and it is inert. You are the power, and if you don't exert yourself and assert yourself you can't wield anything. Your own human effort is the only thing which will appeal to and move others, and it is only when you move others that you move anything. Don't be impersonal, but be yourself with all the fire that nature gave you, and don't be afraid to be yourself—your best self—and let the world judge as it may. You are never so much yourself as when you forget yourself, and you are then unselfish.

All things are more or less hard to do, and work only will do them. Get a right idea of work. Don't trust to cleverness. It is worthy, but it will not do your work. Accomplishment demands singleness of purpose and concentration. All exterior forces tend to diversion from these essentials. Here you come in again to show your triumph of personality over environment. No matter what you do, from the humblest incidental thing of the moment to the consummation of your greatest ambition, the same principles of human activity apply. All will be clear sailing until you meet resistance and sometimes you will run against it hard. Then you will find whether you have nerve or nerves. No one can help you much. Your measure is being taken and you win or lose upon the cumulative ability which you can muster as the total assemblage of native talent and all that has become a part of you through all the influences that ever entered your life. See to it that they all shape one way. You will meet some disappointments through your own faults and some because the world is not exactly just, but whoever gets approximate justice in the world is doing very well. The perfectionist has a hard time. He meets continual disappointment, especially if he is chiefly worried about the imperfections of others.

The nearest you will ever get to perfection is when you get out of your powers all that there is in them. You will find them stronger the less you dilute them with borrowed force. The good you accomplish must be a part of yourself, and whatever you may receive by way of knowledge, experience, and training must be assimilated until it is a part of your own living being before it can be made productive. The capacity to perform is essentially a human creative function and not an act of transmission of what you may have acquired.

You are going to breast a gale, of advancing and ever changing arts, with all their complexities, anomalies, and uncertainties, where "nothing there is can pause or stay." Thus duty is made harder to perform than if you lived in the quiet conventionality of a less enterprising land. Difficulties and their overcoming bring opportunities, and who would ask for ease at the price of stagnation? I believe it was Tacitus who created a solitude and called it peace. However powerful and individual you make your personality, it must in general conform to the well determined laws of effective human procedure. Freaks never win. You may more or less follow the systematized results of practice, but you must obey the laws of purpose, of motive, of integrity, of unselfishness, of diligence, faithfulness, and fidelity to trust. Transgression of these will be punished, while decadent variation will only produce an imitation of the real thing, and all imitations are bad.

I assume that those to whom I am talking are capable of being many times as good and effective as they are now. Effectiveness gets fairly weighed and compensated, financially or otherwise, by the world's scales. You will never be paid for what you are going to do, and you will be only partially compensated for what you have done. There must be a profit in everything, and therefore ability to perform must be bought at one price and sold for another. With growth compensation will grow, and no small part of growth is the ability to rise and do the things that need be done, no matter what they are; to rise from selfishness to unselfishness, from smallness to greatness, and from anything to competency.

There is a wrong notion in the world as to the sequence of some things. You must first perform and re-perform and prove that you can perform and keep it up before you will get credit for performing. A large proportion of the people in the world cannot do certain things because they have never tried, and many have thought they could not because they did not do very well the first time they tried. There is nothing pertaining to your general conduct in the world that you can't do. People become what their motives lead to. Consciously or unconsciously your motives make you, and your practice will follow from what you have thus been made. The personal shaping of one's self along lines however worthy cannot be accomplished through initial intent alone. It requires a burden upon the mind, a mission in the heart and a continuous motive in life's work.

If these things be good, then they are good to contemplate, but contemplation of itself avails nothing. If you ever expect to get anywhere you must move on. It is not always necessary to step lively, but keep moving. There is a tendency in human nature to expect to find a stopping place. The spirit of moving on is the spirit of progression; the spirit of optimistic dissatisfaction. It is necessary to cultivate restlessness in order to have a moving spirit. The fault as well as the fate of the rolling stone is not so much because it rolls as it is that it usually rolls down hill. When you move be sure of your direction.

Progress should mean something. It should mean real advancement in thought, habit, and action—perceptible to one's self and to others. This moving on may be adapted in one form or another to suit different temperaments. To some it should mean moving onward within few and perhaps limited lines. To others the onward movement will involve the constant taking up of new and broad lines of effort. To many it is refreshing as they progress from one period of life to another to awaken new interests, to have new ambitions, new fields to conquer. While to some the activity of this added effort might

seem too strenuous, there is little doubt that to others it is an enriching process which by recreative and interesting variation revives and stimulates mind and body to a condition of existence in which they last longer than if allowed to go to seed.

The least duty of everyone is to make the world just a little better. This can't be done by merely approving and imitating what others have done. You will never do it looking backward. Ambition seeks new seas to sail.

No one should dare to prejudge what any person may do, and to everyone are open all the possibilities of all that has not yet been performed. The lessons of the beaten paths are yours for the pains of acquirement. The inspiration of the successful achievement of others is yours for the heed. The opportunities of the future belong to you for the seizing. All things are always possible and your aspirations should ask

"Is the day of our hope not near—when we
"Will seek for the truth and find
"That the soul's best gifts are lost in the waste
"Of a backward looking mind?
"Shall we make new paths where none are made,
"Shall we strive and at last prevail,
"And at some time build our ship, please God—
"Where there are new seas to sail?"

THE NEXT STEP.

By

Walter C. Kerr, M. E.

This address of Mr. Kerr's gives much sensible advice to young men about to start on the practice of their profession and tells them something of what to do and what not to do, guiding them in the right direction and pointing out the stumbling blocks and pitfalls that lie in their path. Few papers concentrate as much solid advice and valuable precepts in such a small a space as does this one. To appreciate it thoroughly one should read it several times in order to impress its many wise suggestions deeply upon his memory.

Editors.

THE NEXT STEP.

By

Walter C. Kerr, M. E.

This is an important day to nineteen of those whom I am addressing, and it is just as important as any other day to the rest of us. Perhaps the most important moments in our lives are those in which we resolve to do something, and the importance is made permanent when action follows the intent.

I am not going to say much about education. You have perhaps heard as much about that as is good for you, and I have no doubt you have received some, even much. In a way, I am interested in education, but I have more interest in those who receive it.

Educators and institutions are seeking the ideal education, and they will find it when they find ideal men, collected in ideal groups, and doing everything in an ideal way.

There can be no doubt that some methods are better than others, and some facilities excel others, but after all the best thing for any man is that which fits him best. Men differ through so wide a range that about the best approximation to high excellence is the presence of large opportunity, facility, and the personality of many men. With these factors related by force of gravity, attraction, cohesion, friction, and other physical and mental phenomena each person gets that which best fits him and sticks the closest to him.

Therefore in a certain way the ideal education is the education you get, and from a certain set of conditions one man gets one kind and another man another. In these relationships, apparently similar causes do not necessarily produce similar effects, and the effects differentiate largely along the line of the characteristics of the receiving body.

Each of you, therefore, operated upon by similar forces during the past few years, has acquired a different kind of education. This is not so apparent now, amidst the levelling tendencies of the conventionalities by which you are all brought to a certain stage at a certain age, surrounded by the same conditions, and therefore apparently all more or less alike.

This day, however, marks your individual departure from conditions common to you all, and five years will find you translated along many different radii. Ten years will find you far apart.

Up to this time, some one else has done the directing. Hereafter, you will direct yourselves. Perhaps, under certain terms and conditions of employment, you will think some one else is directing you in a rather firm way, but after all you will find that you are directing your own destiny, and the apparent direction of others is but the incidental utilization of your best proclivities and a desirable restraint of your worst ones.

About the first practical thing you will now do is to enter employment, and practically the next thing you will do will be unconsciously to create an impression of what you are good for. That impression will be best made if you will attend strictly to what you are given to do. Do it faithfully, cheerfully, and to your best ability, without trying to create an impression. We all know there is something about a boy that will make him climb a tree faster when the girls are looking on than when they are not, and the momentary stimulation of ambition is likely to produce a fall. When you start out into the world, don't get excited and overdo, nor feel that all eyes are upon you. No one is looking very hard, nor caring much. So just take care of the job you are on, and consider that it is the only thing eyeing you.

Those who have had large experience in dealing with engineering graduates have found them a pretty good lot. They ought to be. Any man who is not has something the matter with him. Whatever he has by the grace of nature, with the addition of what he has acquired by way of fact and instruction, coupled with the training which this has given him, ought to make him capable to an acceptable degree, even if his experience has not yet so rounded his judgment and tempered his acts as to render him proficient.

The employer expects of the young man, fresh from his technical education, ability to understand, capacity to think, the possession of ordinary facts regarding ordinary things, logical procedure in his acts, faithfulness in performance, accuracy in observation, and general intelligence. He does not expect ripe judgment, practical knowledge of technical procedure, trained commercial astuteness, nor does he expect broad perception of the myriad of things more or less correlated with those on which he directly serves. These latter attributes follow from experience, and they will surely follow if the former attributes are possessed and practiced.

It is almost impossible to specify those qualities which most quickly lead a young man to rise from the lower position he first fills to the

next and the next until he becomes a valued assistant and on the high road to leadership, but there is no one thing which so marks a young man in any organization as to be wanted. Young graduates enter manufacturing establishments, engineering offices, or construction corps, —starting evenly in the race. Soon it develops that here and there is a man who seems to be wanted by every department. It would be difficult for those who want him to define exactly why. The man is as yet too young and his characteristics are too unformed to warrant any firm determination of his ability, but in some way or other he is wanted, and opportunity follows want, whether long felt or shortly realized. Cheerfulness in all things is not the least of the factors that enter into "being wanted."

When a man steps up because he is wanted, he must "make good," because this early and only half-formed choice is not firm enough to stand unless warranted by performance. The burden, therefore, upon the man who is chosen is far greater than upon him who is not. Through his ability, diligence, perception, and capacity to render his potential possibilities in the form of practical service, he will find the rising steps always in front of him and will need spend no part of his energy to find them.

As he proceeds further on his way, he may feel that he is doing much and doing it well, and this is about the time that self-centered youth forgets that after all it is only assisting. Some one else is carrying the responsibility. Some one else is the leader, and the effort of the young man has not yet been called to its greatest obligation, because as yet there has not fallen upon it the burden of final responsibility.

The day you get your first serious responsibility will be a far more important day even than this, because that is the day you will either carry the load or not. No one can help you much in preparing for it. This is something you must do for yourself. When the time comes that you take the burden, no Herculean effort of the moment will make you capable of sustaining it. All that you have ever done, are doing now, or are going to do up to that day will or will not prepare you for it, as the case may be, and the ability to carry responsibility is the whole test of leadership. It is not knowledge, skill, brilliancy, nor even genius that makes a man a leader, but only the power to carry responsibility successfully.

This requires a series of attributes beginning with proper self-confidence and ending with wisdom. Somewhere in the line will be found courage, firmness, honesty, and everything that composes high

character. Each man must, therefore, cultivate that which is within himself and make of it the most to this end.

You are going out into the world at a time in which many things differ from their previous condition. One of the most important is that within recent years the whole civilized world has turned from the struggle for existence to the adaptation of the world's needs to the available men to fill them. It is the passing from the ages of insufficiency to a period of surplus.

Orginally in the struggle for existence men fought for food. The race multiplied while the material and facilities for its subsistence lagged. When any tribe or nation succeeded in getting a little more than it needed, some other nation or tribe attempted to take some part away from it. The effort of the individual and the welfare of the nation were practically a struggle for existence. The development, however, of civilization, the arts, and the sciences has produced a rich world. The land more than supports the people. The industries give employment to all who are willing to work, and at a good wage. Broadly speaking, poverty is unknown. Individually, it only exists as a pitiful extreme of incompetence. The world is affluent. Farmers are prosperous. Science has unearthed mineral wealth. Manufacturers are industrious. Enterprise is almost rampant. Everywhere the world is calling for men to do things, and it is willing to pay well for capacity. It is the age of surplus, in which the farmer and the artisan have bank accounts and a few, even many, are rich. Men are not seeking work, but work on every hand is seeking men. This condition is so very recent that it is perhaps not fully realized, but it has come with the present generation, and will have an influence and a favorable one on all men now beginning their world's work.

Meanwhile transportation and all that attends it has increased the radius of individual action, and therefore of personal opportunity. A man can now pass from one grade of employment in a given locality to a higher grade in another locality of a land three thousand miles broad quite as easily as in the early days he could make the change from one neighboring city to another.

Conditions of life, too, are more fixed, and changes of location, even of occupation, involve less of risk, hardship, or of social, physical, or mental disturbance than heretofore. All conditions have, therefore, grown more favorable for every man, with opportunity increasing in geometrical ratio as related to the abilities of different men. The premium on marked ability has, therefore, increased, while the reward for capacity has become more assured. With this, the standards of performance rise as responsibilities grow greater; but to meet this the

facilities enabling the man to make the most of his potential ability at an early age, proportionally increase.

You are, therefore, going out to a well formed world, in which more has been done to prepare it for the exercise of your ability than you have done in the cultivation of your own talent. I do not mean by this that all of the roads have been straightened and the ways paved. The world is still humpy and bumpy, and you will find it hard in spots. Human nature remains unchanged. You will meet the resistance of men and the imperfections of material in this age the same as in any other. You must be strong—not only strong enough to meet the encountered resistance, but so much stronger as to meet it easily and carry a surplus inertia.

It is easy to see beyond the point of good vision. There are conditions under which it is wise to be long headed, but it is also easy to overlook many things close to one's eye, which are the essence of what should be perceived. There is always a bit of added grandeur to that which comes from a distance. The man of high estate from a distant country seems more elevated than the one we know near home.. The expert from afar seems more expert than the man we know too well. It is trite to remark that "Familiarity breeds contempt," but it is too often forgotten that "Distance lends enchantment."

There is something about effectiveness which has to do with grasping things which are within reach and using them, and not speculating on something that is beyond grasp. The possible benefits which can arise through unattainable conditions are of no value. Power is the quick adaptation of things at hand to needed ends. Therefore vision must not be too long. See the things that are near and see them right. See their possibilities and recognize their limitations. Act with reference to them, use them, and keep the horizon within practical working range. This for action, but as a matter of mental gymnastics, as an expanding function, as a matter of mind training, it is well to use the imagination to reach out to any length and to what may lie beyond. Then, before action, draw in the lines to the radius of action which can be made practically effective.

Much has been said from time to time about the inferiority of knowledge gained piecemeal as against its acquirement in substantial masses. The former is liable to be superficial and incorrect; the latter profound and competent.

The scattering of knowledge into little bits covering a wide range is catered to by many forms of literature, whether general or specific, which finish a subject almost before it is begun.

This tends to the scattering of brain effort, the splitting rather than the cementing of intelligence, and to the fickleness of flitting from thought to thought and motive to motive in a manner leaving no fixed imprint on the mind thus operating. It gives also, little more than the appearance of a brilliant film or veneer of learning to those who view its results. It encourages suffusion and dilution instead of concentration.

On the other hand, the concentration required to hold to one subject, and to acquire one class of knowledge through a considerable period of time and carry it over a broad area in which the units of surface are of somewhat like kind, tends to profound acquirement. In quantity, enough is gained to be useful, and in quality it is dense enough to have substance.

All this in a certain way has a bearing upon creative work, and it is creative work only that makes the world move on.

There is no merit in breadth obtained at the expense of depth. All mental effort, acquirement, and knowledge need the strength, constancy, and power which come only by dealing with large masses through reasonable periods of time. This to some extent accounts for the power manifested in some men who have studied little, but what they know is theirs and theirs for use, as against others who have scattered over so broad a range that they have a little of much, not much of anything, and nothing for use. The old maxim of "Do a little and do it well" may be improved into "Do much and do it well."

Science and engineering cannot be picked up from popular expressions or the rambling through attractive descriptions of novelties, but only from the study of the fundamental principles. Therefore read books. Study principles, not novelties. Think theory and work practice. Turn to real sources, not to the tricks of words and platitudes which so often catch one's fancy, and in a superficial way lead to notions rather than to logic.

There is something in the very system of education that constrains one to think that everything must be done systematically. It is hard to say anything disparaging of so good a thing as system. It surely has its place. It has merit. It should be cultivated. But again, it has faults. It has the strange anomaly of being both natural and unnatural. It is natural because all nature grows systematically, evolves systematically, and all profound things move more or less systematically. Nevertheless, much is encountered that seems to know no law, and chaos is not always best met with system. Many things from warfare to commerce show that system vigorously and profoundly applied will win against force used indiscriminately, but, whatever of such truth may be

derived from generalization, one should not lose sight of the plain concrete fact that a refinement of system does not always best fit practical conditions as they exist. Such conditions often demand going straight at the obvious mark regardless of system.

It may be observed that system is cultivating, and it is, therefore, well to cultivate system,—but with it cultivate the capacity to break through it temporarily, effectively, and for good cause.

To succeed, you must above all things be what the world calls practical. The practical man is the one who understands the things about him.

Foresight is the carrying beyond present view the knowledge of things within view. It is the practical man who displays foresight and thus is called wise, or prudent, because through the knowledge of things about him he can extend his judgment to those beyond.

Knowledge in the form of learning is inferior to knowledge in the form of discernment, because it is less effective. The former may be admired, but the latter is followed.

The boy who "wants to know" is the right kind. Get next to everything next to you. You can't successfully deal with large things far removed unless you understand the small ones near by.

The practical man thinks quantitatively and qualitatively, while the impractical man thinks qualitatively only.

The failure to recognize quantitative analysis in mental action is responsible for many misconceptions, poor judgments, and worse acts.

Too many men allow their minds to form judgments on a qualitative basis only, so neglecting the quantitative as to reach wholly wrong conclusions. The question of many things is not whether, but how much. To realize that one thing is better than another is of little importance unless one determines how much better it is. The value of the fact that one cost is greater than another is measured wholly by how much it is greater. Perspective is a relation between size and apparent size. The effective man has an ever present sense of proportion. The dreamer does not so relate things to each other as to make their ratios real. The habit of quantitative analysis and the attaching of quantitative values is of even more importance than a general idea of qualitative relationship.

Express yourselves. There must be an impulse to expression. Follow it without fear. Thinking twice may be overdone. Think right once to act. The impulse to act on every point of knowledge is inspiring—even if conditions restrain action. It is the desire to act that causes activity, and nothing but action can produce results.

As a last short word, I ask you to be individual. Base your individuality on correct knowledge of fundamental principles. Make them your own and not merely things that were told to you or what you may have read about in books. Make them your own so firmly that you understand them with the fullness of your own nature. I mean not only the natural laws of physics, chemistry, and economics, but the laws of right and wrong, the principles of equity and inequity, the comprehension of the essence of things as distinct from the incidents; a realization of commercialism and its ever constant relation to the effective application of all laws; a clear perception of facts, and ability to use the five senses as well as the one brain.

Never mind conventionalities except so far as they are good when measured in terms of higher laws than set forms. At least one-half of all conventional methods in the performance of the technical arts consists of the persistence of inferior methods utilized only because retained through precedent.

Above all, be courageous, consistent, considerate, and cheerful, in order that your talents and the best attributes of your nature may have fair play in a world that wants your service so long as you render it in the right spirit.

COMMENCEMENT ADDRESS.

By

Dr. Julian Kennedy.

This address was delivered on June 3, 1909, to the graduating class of Stevens Institute of Technology, and was repeated a week later to the graduating class of the Pennsylvania State College. Dr. Kennedy is one of the most distinguished of America's numerous mechanical engineers, his specialty being connected with the manufacture of steel. Everywhere, both at home and abroad, blast furnaces, steel works, gas producer plants, rolling mills, slab mills, plate mills, tube mills, power plants, railway bridges, sugar mills, hydraulic dredges, and tall buildings bear evidence of his rare constructive skill.

In consequence of his wide experience, extending over a period of thirty-six years, his advice to young men about to start in the practice of engineering ought to prove of immense value. Anyone following it is certain to obtain great benefit, and it may prove the means of his attaining professional success.

Dr. Kennedy's professional record is as follows:

He was born at Poland, Mahoming County, N. Y., March 15, 1852, and was educated at the Poland Union Seminary, then at Sheffield Scientific School of Yale, where he took the degree of Ph. B. in 1875 and that of A. M. in 1900. Before going to Yale he had been draftsman, under his father, in the construction of the Struthers Iron Company, where he was employed three years.

From 1876 to 1885 he was Superintendent of Blast Furnaces at the Briar Hill Company's works, the Struthers Iron Company's works, the Morse Bridge Works, the Edgar Thompson Steel Works, and the Lucy Furnaces. From 1885 to 1888 he was General Superintendent for Carnegie, Phipps, & Company at Homestead; then for a year or two he was Chief Engineer of the Latrobe Steel Works. Since 1890 he has been a general consulting and contracting engineer with headquarters at Pittsburg, Pa. He has been connected in some manner or another with nearly every important steel plant in the United States and Europe; and he has patented many improvements and devices for manufacturing iron and steel.

He is a member of several of the leading technical societies of America and England.

Editors.

COMMENCEMENT ADDRESS.

By

Dr. Julian Kennedy.

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Assuming that the majority of you will follow engineering pursuits, it may not be amiss to mention some things which you will have to deal with in your future work. It is entirely unnecessary for me to remind you that most of you are not at the present time engineers. Those of you who have properly utilized your opportunities have received a splendid mental training, together with some knowledge of engineering which equips you to go on and acquire the vast amount of practical knowledge necessary to the engineer. You will soon find that many kinds of knowledge which you have perhaps considered useless, are important and essential in your professional work. It is a mistake made by most students, and I have no doubt many of you have made it, to think that the Faculty of the school has introduced too many general studies into the course instead of giving all, or nearly all, of the time to purely technical studies and practical work closely related to engineering. To those of you who have had this feeling, I would only say that your views will change as you go on and in ten years from now you will think more of the judgment of the Faculty in these matters than you do at present. There is no doubt that your instructors could map out a course which would turn out graduates who would be able to start in practical work with much more ease and readiness than you can, in fact any boy who had spent the four years you have spent here, in the field or drawing room learning practical engineering, would, other things being equal, be able to do routine work in an engineering office much better than you could do it, but, on the other hand, in a very few years you should be far ahead of him. In other words, "your instructors have been wise to give you a broad and liberal training, and to forego teaching you some of those things which would come nearest to making engineers of you at the time you finish your course in order to give you more of the broad and fundamental principles, the mastery of which will enable you in a reasonable time to become much abler and more valuable engineers than if your training here had aimed to teach you the maximum amount of that kind of technical information which is supposed to be most immediately useful

to the young graduate. It is much better for you to have a broad, liberal education and a little engineering knowledge when you leave here than to have a much greater amount of practical and technical knowledge without a liberal education. In your future work you will learn that it is much easier to find among technical graduates good designers of machinery or fine mathematicians than it is to find those who can write a satisfactory contract or even a good business letter.

At some stage of your career some of you at least will be called upon to purchase large amounts of machinery and materials, when you will find that the ability to write a contract from which not one word can be omitted and of which not one sentence can be construed in more than one way, will be of more value to you than even a knowledge of the method of least squares, which some of you may perchance have forgotten by that time. Not only will your opinion of the judgment of the Faculty change, but your general impressions of them will also be radically revised. In my student days there was a song, the refrain of which was, "There'll be no Faculty there," but after graduating you will begin to appreciate the Faculty and year by year this appreciation will grow stronger until you will finally arrive at a somewhat adequate idea of what you owe to them and to realize that not to its buildings, not to its endowment, not to its alumni does your institute owe its greatness, but more than to all of these combined to that noble, earnest, unselfish, self-sacrificing band of men, its Faculty, and as the years roll round you will appreciate how many of them have given up the chance of much greater material reward in other lines of work in order to do the more important work of fitting you to be an honor to your school and a benefit to the world, and at the end of a quarter of a century those of you who are living will be amazed at the interest taken in you one and all by the Faculty, who, like a mother, never forget their boys and grieve over their misfortunes and glory in their success.

Speaking of mothers brings to mind mothers-in-law. Like college faculties, they are often the subjects of jokes, but if you will observe carefully and accept the verdict of those who have had experience, you will learn that one of the truest and best friends a man has in this world is apt to be his mother-in-law. In this connection I may say that one of the things most essential to his success, which a young engineer should do not too late in his career, is to acquire a mother-in-law.

I have spoken of the engineers purchasing materials and making contracts, which leads to the thought that a large part of engineering is commercial, and that commercial considerations must be given

weight in all engineering work. We are sometimes inclined to forego these and strive to produce something ideal, without reference to the question of whether it will be profitable or not. The man who puts in an elaborately designed machine to displace two laborers in a plant and finds that instead of them he has one skilled man operating the machine and two high-priced machinists keeping it in repair, may be a genius and a skilled mechanician, but he is not accomplishing what is generally wanted. You will be surprised when you get into actual work to find how often commercial conditions are ignored by engineers, and not by engineers only. It may be your experience at some time to work hard for weeks at the urgent demand of a board of directors to try to reduce the cost of labor in a plant by five or ten cents per ton of product, and you may spend many thousand dollars to accomplish this, while at the same time the output of the works is being sold year in and year out at a dollar or two a ton below the price it ought to bring. You will find also in many cases that costly machines are installed to effect savings which are offset many times over by the interest on the cost of the machinery and its maintenance. You will also find installed elaborate and intricate machinery to effect the highest ultimate saving, which because of the complication becomes unreliable and subject to breakage, and you will be surprised to find in how many cases an hour's stoppage of a machine which forms part of a large and highly organized plant will cause a loss of more money than would be saved in a year by this highly efficient machine as compared with a less efficient but thoroughly reliable one. The larger and more complicated a plant is and the more highly organized the sequence of operations carried on in it, the more important it is that all machinery in it should first of all be as reliable as it can be made. It should, therefore, be your aim to acquire as rapidly as possible, in addition to your mechanical ability, good commercial judgment and a wide experience, enabling you to judge which of several different paths is apt to lead to commercial success. In purchasing materials the engineer often has to act as the agent of his clients as well as a referee between them and the seller. It is, of course, his duty to get materials as cheaply as possible, but he should never forget that he ought to be absolutely fair to both parties, and the engineer who maintains this attitude will in the long run best serve the interests of his clients as well as his own. In doing business he should remember that nine-tenths of the litigation in this world is caused by vague or incomplete understandings between buyer and seller, and he should exercise great care to see that everything connected with the specifications and contract is so fully and clearly expressed that there can be no misunderstanding regarding them, and he

will find that to do this is by no means an easy or simple undertaking.

In starting out as engineers, you should all bear in mind that you are largely dependent upon others. The field of engineering is so vast that no one can cover a very large part of it, and no one can accomplish much unless he has the faculty of availing himself of the work and knowledge of others. The man who makes one of the greatest failures in the mechanical world is he who spends his life inventing complicated machines, only to find that others had invented them years before. In many lines of work it is just as important to know what has already been done as it is to possess great ability to originate new designs, and as between the man who is an expert special designer in any department of engineering and the one who has the faculty of utilizing the work of many other men in many departments, the latter will be the more valuable man, will be more sought after, and will rise higher in his profession. In other words, it is not so much what a man can do himself as what he can get others to do that makes him valuable in carrying on large undertakings.

In your work as engineers you will be called upon to make reports on properties, processes, etc. You will, of course, in such cases be sure that you understand the subject, after which it will be wise for you to write your report so as to say in it all you desire to say and write it on the theory that anyone may read it. You may be asked sometimes to vary the wording of your report on the ground that it is not to be published, but only shown to A or B. In such cases you will be wise to make no changes which you would not want read and criticised by anyone, and to bear in mind also that the funds of widows and orphans may be invested in enterprises on the strength of your report. Your written report, should, of course, be complete in itself, and should not need to be supplemented by oral explanations, and it should be so concise and clear that there is no possibility of anyone warping or distorting the meaning of it. While most business men want straight, honest reports, there is quite a respectable (as to numbers) minority who will try to have you warp the truth just a little, and who are very plausible and specious in the way they go about it. In work of this kind you will find that commercial knowledge and good judgment play a very large part, and you will possibly learn that expert accountants, like many other kinds of expert specialists, are very narrow in their views and more or less feeble in grasping broad principles. To be successful in this line of work it is necessary that you should acquire a great deal of general information in connection with accounts, construction of plants, and their operation. You will also find many things in works which cannot be seen, and for your information in regard to

them you will be dependent upon other people, and your success in getting accurate information will depend largely upon your judgment of men, your tact and ability to elicit correct information from them. Owing to the large number of things which have to be examined sometimes in a very short space of time, it will be necessary for you to acquire a faculty of seeing things quickly and accurately, as well as of judging of their conditions and their methods of operation. This is a faculty which varies greatly in different men, but one which can be cultivated to a marvelous extent.

You have doubtless seen men who could walk through a factory and come out with a wonderful amount of information regarding the workings of a large number of intricate machines, whereas another man may have passed through at the same time and not seen a hundredth part as much of the actual inwardness of the mechanism. In making reports in regard to works or plants, you should be as concise and clear in your descriptions as possible, bearing in mind that bankers and financial men generally are apt to place upon a report a value in inverse proportion to its length. I remember seeing a report on a large plant containing some miles of railroad trestle, which gave in exact detail the size of every sill, every post, cap, corbel, and stringer in the entire works, the list occupying a good many pages of legal cap; and the entire trestle was rotten to an extent that it was not even fit for firewood, and the only thing that was really necessary to know about it was the expense of pulling it down and hauling it away. The man who made this report was probably a very painstaking engineer, but lacked something in his makeup.

You will in your future work, doubtless, be called on to testify as experts in the courts in cases involving mechanical considerations and patents. There has been a good deal of criticism of the system of having experts on each side of a case, and many have recommended that the court should engage its own expert, but all things considered, I have no doubt that a fuller, broader, and fairer knowledge is gained by the court if it listens to two experts each putting forward the strong arguments for his own side of the case, than if only one expert is heard, as he is liable not to see all sides of the question, and may, with the best intentions in the world, give a very incomplete and erroneous opinion on the technical points of the case. This is less likely to happen where each expert sets forth his own side of the matter, and is cross-examined by the other side. Should you have occasion to act as an expert in this line you should first of all be sure that you have a thorough knowledge of the subject; in other words, that you are a real expert in it. Next you should endeavor to be entirely

fair in your testimony. It is not expected that you should volunteer aid or assistance to the other side, but you should answer all questions fully and fairly, and, above all, you should be absolutely honest in regard to your opinions. As a general rule, it is wise not to enter a case unless a preliminary study of it convinces you that you can be of service to your client, and at the same time adhere strictly to your honest opinions throughout. You will find it essential in this kind of work to be patient, to have absolute control of your temper, and to meet the most insulting and irritating cross-examination with unruffled composure and with retorts courteous. Where the facts are against your side, you should not try to dodge the issue, but remember that frank admissions of those things which plainly favor the opposition in most cases help your side more than they hurt it. Remember always that although it may be impossible to prove that a statement of an opinion is not truthful, yet an experienced judge in reading the testimony will almost infallibly detect any tendency to untruthfulness or unfairness in a witness.

In your engineering work you will possibly have to direct large bodies of men, and here you will need judgment, tact, and knowledge of human nature, together with firmness and decision and a spirit of fairness. In addition to handling men successfully, you should make it a rule to learn from them, and you will be surprised at the great amount of information you can gather in this way, especially among mechanics. Twenty or thirty years ago there was, among the so-called practical mechanical men of this country, a good deal of contempt for the technical graduate. This feeling has to a large extent ceased to exist, but on the other hand I fear there is a tendency on the part of the technically trained men at the present time greatly to underestimate the value of the knowledge of the first-class mechanic acquired by long practical experience. Many engineers would rise much higher in their profession if they had the faculty of absorbing useful knowledge from the working mechanics, many of whom have wonderful ability and can give most valuable information. In a still wider sense engineers can get a great deal of information from their brother engineers, and team work is just as essential in carrying on engineering work as it is in winning a game of football. As you can obtain a large amount of aid from other engineers, so it should be your duty and your pleasure to impart information to your engineering brethren, especially to the younger members of the guild. Make friends among men of high standing and greater experience than your own and hold them. Always see a desirable position ahead of you, and strive to be prepared for it mentally and physically. Remember that often a strong constitution

and vigorous brain will cause you to win where others have failed. Bear in mind that booze and business do not mix, and that the demand for sober, steady men grows stronger. In men as in machinery what is most wanted is reliability. In all things so shape your actions that if failure comes to you, you shall have done better than to achieve success by deserving it, and so that you can inscribe upon the dismantled mill or the abandoned mine "all is lost save honor."

Gentlemen of the Graduating Class, I congratulate you upon the future which looms up before you. The great advances in science, mechanics, and all of the forms of material and mental development achieved during the last fifty years will be dwarfed by those of the next half century. Your native land possesses most marvelous resources and boundless possibilities. Its great forests which should be conserved and increased, its vast water powers to be developed, its great stores of fuel to be economically utilized, and other natural resources too numerous to mention, all of which should be used in the most efficient manner, call for earnest, faithful, and intelligent engineering work.

A part of this work it will be your good fortune to do, and I have no doubt you will do it vigorously and faithfully, and will receive the reward which follows work well done. You will find discouragements, but these come to others as well as to engineers. The financial rewards of your work may seem small as compared with those common in other professions, but there are other rewards besides these. The man who builds a successful machine enjoys a pleasure which the owner of it does not, and the engineer who sees scattered over the country great plants which he has designed, doing their work well, obtains a great reward even if the financial return to him is small compared with that received by the stockholders.

In addition to the work which you will find to do in the line of engineering, it is to be hoped that your influence will be widely felt in other directions. There are many problems in connection with the municipal, state, and national government that will require solving in the years to come, and no class of men should be more able to cast their influence in the right direction in the solution of these than the engineers. When you consider that the cost of building and maintaining one modern battleship is greater than the amount necessary to endow and operate Harvard University, Yale University, and Stevens Institute, or again that the first cost of one of these vessels would build five thousand model workmen's homes costing $3,000 each, and when we see further the insane rivalry between such great powers as England and Germany to see who shall have the most of these engines of destruction, while at the same time both countries are rapidly drifting

toward bankruptcy, it seems as though the time were ripe for educated men and everyone else to use their influence on every possible occasion against this species of folly.

When we further notice the so-called alleged statesmen who represent the various portions of our country at Washington quibbling over trifles and striving with all their might to get all the plunder out of the public crib for their own districts, and failing to take any action on the great questions which would be of untold benefit to their country, it impresses us with the fact that there are needed in this country a great many clear-headed, courageous men who can think straight and are not afraid to express their opinions. There are, and will be, many important questions arising, and it should be your duty and your pleasure to use your influence at all times in favor of any policy that will make for the good of your country and your fellow man.

I trust you will not be content to be simply skilled mechanical specialists of the type that looks with contempt upon Shakespeare and Milton because they knew nothing of alternating current generators or Pelton water wheels, but that you will strive to acquire a broad and liberal culture, kindly sympathy, and sound judgment; that your influence will be steadily exerted in behalf of all things that are of good report in social, civic, and national life, and that, wheresoever you may be, at all times and in all places your Alma Mater may be proud of you, and that your country and the world may be better for your having lived in it.

To you, Gentlemen of the Graduating Class, who, by successfully completing the thorough and strenuous course demanded of you by this Institute, have demonstrated that you have the ability and industry to acquit yourselves with credit in any work your hand may find to do, my parting greeting is,

"Well done and go forward."

STUDY MEN.

By

John F. Hayford, C. E.

This address, which treats of a most important subject not only for young engineers but also for all young men, was given in 1907 to the graduating class of the Thomas S. Clarkson Memorial School of Technology. Mr. Hayford then held the important official position of Inspector of Geodetic Work and Chief of Computing Division in the Coast and Geodetic Survey Department at Washington, D. C.

The introductory portion of this address treats of the magnitude and importance of the engineering profession, a subject that cannot well receive too much attention in the curricula of technical schools, but which unfortunately as a rule, is generally ignored.

The advice to study men is the soundest of the sound. Doing so will enable you not only to benefit by the labor of others but also so to mould your own character as to incorporate in it the good traits of others and reject the objectionable ones. There is an important deduction to be made from Mr. Hayford's discourse—something in the nature of a corollary—viz. "Study the lives of eminent successful engineers" in order to learn how and why they succeeded; and before reading any technical treatise learn all you can concerning the life history of its author. This, to say the least, will make the study of the book more interesting, and probably also more profitable.

Mr. Hayford was born at Rouses Point, N. Y., May 19, 1868. He graduated in the Civil Engineering Department at Cornell University in June, 1889, and was immediately appointed computer in the Coast and Geodetic Survey as a result of a civil service examination. In 1890 and 1891 he served as computer in the Tidal Division, in the office of Standard Weights and Measures, and on a base measuring party at Holton, Indiana. In 1892 and 1893 he was Assistant Astronomer to the International Boundary Commission (United States and Mexico) in charge of the field operations of astronomic determinations (latitude and azimuth on the whole line), of certain triangulation, and of ranging out 230 miles of the line.

In 1894 and 1895 he was at first Aid and later Assistant on the Coast and Geodetic Survey, doing principal field work and latitude and longitude observations in connection with the Alaska Boundary Survey.

From 1895 to 1898 he was Instructor in Civil Engineering at Cornell University.

From 1898 to 1909 he was again on the Coast and Geodetic Survey, at first as expert computer and geodesist, and later in the position of Chief of the Computing Division and Inspector of Geodetic Work. In this position he had charge, under the Superintendent's direction, of the operations of triangulation, leveling, astronomic determinations, and gravity determinations, from the forming of the plans for field work to the publication of the results, having supervision over the field as well as the office operations.

In 1909 he was appointed Director by the College of Engineering at the Northwestern University, which position he now holds.

He is a fellow of the American Association for the Advancement of Science, and a member of the Western Society of Engineers, the American Society of Civil Engineers, and the National Academy of Science.

He is the author of numerous important papers, mainly on astronomical and geodetic subjects, and of two standard books, viz., "Geodetic Astronomy" and "The Adjustment of Observations by the Method of Least Squares."

Editors.

STUDY MEN.

By

John F. Hayford, C. E.

We are met to celebrate the graduation of a group of young men from this institution, the Clarkson Memorial.

I congratulate you, graduates, on your entrance upon your life work in the noble profession of engineering. It is a profession in which there are great opportunities for service.

Your predecessors who have done their part as engineers in turning the forces of nature to the use of man have changed this world from one in which the winner was the man with the brute strength and physical bravery which gave him the power to win in a hand to hand battle. It was a world in which all, even the fighters who secured the spoils and the kings who ruled the fighters, lived in comparative discomfort. It was a world in which the higher thoughts, aspirations, and the impulse to render unselfish service which are the essence of civilization, came to but very few. The mass of humanity were too heavily loaded with hard labor, with real oppression from the classes above them, and with the effects of ignorance and superstition, to have a part in the crude civilization which existed. It was a world in which men knew only their nearest neighbors, in which nations perpetually fought against each other, in which each people was densely ignorant of every other and correspondingly suspicious.

By turning the forces of nature to the use of man, your predecessors as engineers have changed this into a world in which the winner is the man who thinks clearly, controls himself, and may be depended upon,—the man who serves rather than the man who fights. It is now a world in which millions live in greater comfort and security than did even the kings of the ages before the engineer. It is now a world in which the average man works such short hours and under such comfortable conditions that he has abundant opportunities within his reach to share in the real benefits of civilization, to develop himself to his full capacity.

Perhaps you think I have exaggerated in crediting the engineer with all these changes. In terse statements there is apt to be some exaggeration. But, the more carefully you study this matter the more

evidence you will find of the truth of these statements and the more enthusiastic you will become over your profession.

Think for a moment how the steam engine and other machines are the basis of your comfort. Think of the large part they have played in furnishing you the light and heat you have in your houses, the clothes you wear, the food you eat.

The locomotive, the marine engine, the printing press, and the telegraph, have made all the peoples of the world acquainted and changed them from enemies into friends. The people of the United States and the Japanese, living on opposite sides of the world, are better acquainted and more friendly today than were the French and the Prussians one hundred years ago, living as close neighbors.

The engineer by producing powerful weapons and the means of concentrating troops quickly has made war so costly and so deadly that we must credit him with being a most efficient peacemaker.

In improving personal morals, as well as national morals, and thereby advancing civilization, the work of the engineer is extremely powerful. He builds a smooth steel road and a one hundred ton locomotive which draws a massive train at a mile a minute. Then it is found that the safety,—the lives,—of the hundreds of passengers on the train depends upon the quick and certain action of the man in the cab of the locomotive. He must not only see the faint danger signal within a few seconds, every time it appears before him, but also he must not fail to act promptly and with good judgment, or he will pay the forfeit with his own life and possibly with the lives of many others. This and other situations, created by the engineer, in which certainty and quickness of action of the nerves and brain are absolutely necessary, because great responsibility is concentrated on one man, have been most powerful influences in changing this from an irresponsible, drunken world into a responsible, temperate one. You never heard of a railroad company claiming that it needed to provide a canteen to keep its employees sober.

I congratulate you on joining a group of men who are doing great service for the world,—a service much greater than the world appreciates it to be,—a service much greater than the engineers themselves realize. One of the prominent characteristics of the average engineer is that he is so wrapped up in his work as to see only its immediate results and to fail to see its much greater indirect effects. He fails to realize fully that he is working through men and for men,—that the most important effect of his work is its influence on the onward and upward progress of man.

It is because this is my opinion of the engineer and his work that I have all that I can possibly do to live up to the title C. E.

I come to urge you to study men. Why? Because much of your learning is done through other men, because you will do your work through men, and because men are so difficult to understand that careful study is required. Men are the most important objects of interest that will come within your sphere of knowledge. I urge you, graduates, to study men because I am safe in saying that there are some among you who will fail to be useful in the world simply because you will fail to understand men until it is too late.

Please note that you are urged to study men for perfectly unmoral reasons. You are not urged to study men to learn how to improve their morals, not for any effect it may have upon your own morals. You are urged to study men in order to make yourself more efficient as an engineer,—the purpose for which you study steel or concrete.

I have said that you should study men because much of your learning is done through men. Have you ever considered how large a proportion of the stock of knowledge and wisdom you have gathered has come to you through other men's brains?

You, graduates, have been under the continuous influence of the teachers in school and college for 16 to 20 years,—for more than three-fourths of your life. You have acquired through their efforts. They have guided, encouraged, and inspired you. To a large extent your knowledge has been selected by them and your views colored by them. You have learned from and through your teachers rather than from direct contact with facts.

During this school and college period you have learned much from books rather than from teachers. But a book is simply the ideas of a man made visible and explained in the way which seems best to him. You seldom think of the man behind the book. But when you read and study a book you are learning through the brain of that man. Your ideas are influenced, guided, colored by him. To get the full value of the book you should know the man.

If you prove to be a successful engineer, you will pass through three periods with reference to the acquisition of knowledge and wisdom. First, the school and college period when you acquired through books and teachers. Second, the period comprising the first ten or more years after you leave college, the period during which you will occupy subordinate positions and be in close contact with material facts. By that close contact with facts you will gain experience which will remedy, to a considerable extent, the inevitable defects of any education furnished by books and teachers alone.

Just as rapidly and as certainly as you gain real success by showing ability to make yourself useful in the world, and by using your ability, you will find your responsibilities increased, the demands upon you increased, and will find that you cannot, if you are to accomplish most, remain in direct contact with all the facts of your daily work. You will enter the third period with respect to the acquisition of knowledge and wisdom. You will find yourself in a position where you must acquire knowledge through your subordinates who are themselves in more direct contact with the facts. The chief engineer of a railroad, the chief engineer of a great government engineering bureau like the Reclamation Service, the head of a great technical school, necessarily sees the facts of the work for which he is responsible mainly through the eyes and brains of his subordinates. In the third, or executive, period then, as in the first, or school period, the successful engineer acquires knowledge and wisdom by utilizing the brains of other men.

When you are in school and college you are, as a rule, learning things which were well known long before your time, you are acquiring knowledge which is well organized by the successive efforts of many men, teachers, and authors. Because it is well organized knowledge, already worked over by many men, this concentrated experience comes to you from the past with comparatively little coloring due specifically to the last author and the last teacher in the series through which it passed to you. But it does come to you with high coloring and in a distorted form, because the long series of authors and teachers have, as a rule, belonged to one profession,—teaching—because they have all been thinkers, rather than doers. It is within your power, to a great extent, to remove the inevitable false coloring, and to round out the inevitably distorted form by heeding your own experience to be gained in the second period already referred to,—the period during which you are to be in engineering in subordinate positions in close contact with facts.

But as you gradually, by being successful, pass into the third period in which you again depend upon utilizing the brains of others, you will find that the facts you must deal with have not been known long, that they are not well organized, that they come to you through one man or through a short series of men only, and that as a rule the relations between the facts are but dimly perceived by the men from whom you get them. Under these conditions the facts and principles come to you highly colored and greatly distorted and but dimly outlined because of the peculiarities of the man, or the few men, through whom you get them. It becomes, therefore, of prime importance to

you to understand that man, or those men. To be entirely successful you must study men.

I say, advisedly, that the facts with which you must deal in the third period are of this character. The well known and well organized facts and principles will be dealt with by your subordinates without coming to you for attention.

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I have urged that you study men because you learn through men. When you have learned and come in turn to do, you will find that your work must be done through other men, as a rule.

An engineer does very little directly without the intervention of other men between him and his accomplishment, even when he is in minor, subordinate positions. Even the levelman is dependent on his rodman and recorder. The inspector on construction may see with his own eyes, but he produces changes only by operating through a foreman or perhaps a chain of several men, including the engineer to whom he reports, the contractor, the contractor's foreman, and finally the workmen. The draftsman may seem to be directly in contact with his work but he really accomplishes something only as he succeeds by means of drawings in guiding the skilled workmen whom perhaps he never sees. In each of even these simple cases the effectiveness of the engineer is conditioned in part on his accurate understanding of the thoughts and feelings of the men through whom he works.

As an engineer rises higher in the organization with which he works, his field of influence becomes larger, but the line of men through whom he works to produce material results also lengthens He works to an increasing degree through other men and it is of increasing importance that he understands other men. Or, if he fails to know men he is apt to fail to rise.

An engineer works through other men not connected with him in any organization by convincing them of the correctness of his view, and of the advisability of doing certain things. He produces results in these cases by convincing. It may seem at first sight that in this respect a man works in a different way through other men according to whether they are his subordinates in a close organization or are outside the organization. But experience will show you that there is no real difference. You can be effective in producing results through your subordinates in an organization only by convincing them that you are right, though it may not be necessary that they understand why your decisions are right. If you do not convince, your subordinates will accomplish whatever is within their native ability to accomplish unguided, but no part of that accomplishment will be due to you.

If you are to succeed,—to be valuable in the world—to know is not enough, you must make others to know. Your power of passing knowledge from your own into another man's mind depends largely upon your understanding of that man. Hence you must study him. If you understand him and have a thorough mastery of the topic in hand, then your success in convincing him still depends largely on your skill in using language, in making words effective carriers of ideas. Language is one of the tools of an engineer,—a tool which he has frequently neglected because he has as frequently failed to realize that men are also his tools.

As soon as you are well started in studying men you will find yourself studying the need and purpose of organization. For as soon as you fully realize what great differences there are in their principal characteristics, and even how widely the capabilities of a given man may vary at different stages of his life, you will realize why and how it is that a group of men working together as an organization may accomplish much more than the same men could if they worked independently, as individuals.

A very common conception of organization is that it is an arbitrary arrangement by which orders are transmitted by various steps, through different groups of officials, from the man at the head of the organization to the many men who form the rank and file and do the actual work. Many graduates have shown that they believe that the way for a man in a high position to get a thing done is to order it done. Poor and inefficient administrators may do it that way. The successful administrators are men who act on the principle that their business is to administer unto those below them in the organization in three ways. First, by putting them into such places and under such conditions that they can do their best; second, by giving them orders necessary to show what is expected of them; and, third, by enlisting their wills as well as their bodies and minds in the work of the organization so that they will do their best. The first and third of these, the average graduate has never seriously thought of. He sees in the administrative officer the man who orders. The successful administrator finds his time so thoroughly filled with the first and third kinds of administration, with putting each man in the place and under the conditions most favorable to his effectiveness, and with enlisting in the service the will of the man, that orders fill but a small part of his horizon.

The men near the top in an organization normally do the most difficult work. Normally they are the men who work most intensely and for the longest hours. In the great organization with which I am

connected, the civil service of the United States, this is so commonly recognized that it calls forth no comment to see the rank and file leave at four-thirty and come at exactly nine, while others who are in responsible control of the organization work early, late, and strenuously.

I have urged you to study men, and especially to study men from a certain point of view,—the point of view of one who wishes to attain success as an engineer. You may properly ask how it is proposed to study this subject. Study it as you should study any other engineering topic. Use the best books you can find, study current practice as shown in current literature, study the facts and principles directly whenever you can.

You will find at the outset that no one existing book will serve as a text-book. There certainly are fundamental principles, capable of being put into words, which are daily being applied by successful administrators. But these administrators do not put them into words themselves. They are too busy. Some of them will tell you that they act by intuition. If the principles are put into words it will be done by some one who makes that his chief aim for the time being, some one who will study carefully the words (spoken and written) and the acts of successful administrators, and perhaps failures in that line also. That is the way the excellent text-books on various courses in engineering have been built up, and the transition made from the time, only two generations ago, when Mahan's Civil Engineering was the single text-book, to the present state of affairs when we have complete and well written text-books in each of many lines of engineering, as, for example, Masonry Structures, Bridges, Hydraulics, Sanitary Engineering, and so on. It was the teacher rather than the successful engineer who put into clear, definite, teachable form the principles used by engineers. So you must not expect the man who is successful in dealing with men, the successful administrator, to tell you how he does it. You must directly, or through others, watch his actions and their effects, listen to his spoken words, and read his writings on all sorts of topics.

To sum up: You have in your four-year course been studying material things, the facts of nature and the laws of nature. You have been acquiring that engineering knowledge, knowledge of the forces of nature and the strength and properties of materials, which is absolutely essential to your success as an engineer. You have studied man comparatively little. You have acquired your engineering knowledge largely through men and will continue to do so. The soundness of your engineering knowledge depends in part upon your knowledge of men; but what is still more important the effectiveness with which you will use your engineering knowledge depends very intimately upon

your knowledge of men. Hence, you are urged, as you do your part in the world, to study men as well as engineering. You are urged to pay attention to all phases of the men around you, to see and appreciate them as literary and artistic men, as well as technical men, as men of feeling as well as men of thought, as incarnated motives as well as thinking and working machines.

To attain to the highest success as an engineer you should not only be able to reach correct conclusions quickly when you have the facts before you for direct observation. You should also have the power to draw correct conclusions quickly from information which comes to you through other men. This power comes largely from knowing men.

To attain to the highest success as an engineer you must not be the type of man who knows how to do things excellently but cannot tell others how to do them,—the man who gets knowledge abundantly but can apply it only through his own fingers. Instead of devoting your energy simply to increasing your own output by fifty or even one hundred per cent, it is far better,—you make yourself more useful to the world—by using your energy to increase the output of each of one hundred men by ten per cent. The world recognizes this by awarding the prizes to the administrators.

CRITICISM OF THE ENGINEERING SCHOOLS.

By

Professor Dugald C. Jackson.

Unfortunately, most of this address, which was delivered in November, 1909, to the Stevens Engineering Society of Stevens Institute of Technology, is hardly suitable for the purpose of this book. A few extracts from it, however, may be read by students to advantage, and they are here reproduced, both on account of their value and to provide a specimen of the technical writing of one of our leading instructors in electrical engineering. Prof. Jackson occupies that chair in the Massachusetts Institute of Technology.

He was born at Kennett Square, Pa., Feb. 13, 1865, and was graduated with the degree of C. E. from Pennsylvania State College in 1885; then he went to Cornell University for two years of post graduate study, specializing in electrical engineering.

In 1887 with two other electrical engineers he organized the Western Engineering Co., which soon established an extensive business in electrical work, notably in connection with the Sprague System of traction. In 1889 The Western Engineering Company and its business were purchased by the Edison interests, then Professor Jackson became Assistant Chief Engineer of the Sprague Electric Railway and Motor Company with headquarters in New York City, but operating all over the United States on the introduction of the Sprague System of electric railways. When this Company also was absorbed by the Edison interests, Mr. Jackson moved to Chicago to take charge of the Central District for the combination.

In 1891 he accepted appointment as Professor of Electrical Engineering at the University of Wisconsin, where he continued as head of the department until 1907, when he was elected to a similar position in the Massachusetts Institute of Technology, which position he still occupies.

In addition to his teaching Professor Jackson attends to a large consulting practice, which, however, is mainly handled by his brother, as his own energies are principally devoted to the development of his department at the Institute, in which work he has been eminently successful.

He is a member of many of the leading technical societies of America, and has been honored by the presidency of two of them, viz., the Society for the Promotion of Engineering Education and the American Institute of Electrical Engineers.

He is the author of a number of valuable papers and standard text books on Electrical Engineering subjects.

Editors.

CRITICISM OF THE ENGINEERING SCHOOLS.

By

Professor Dugald C. Jackson.

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How many of you young men, students of engineering, composing this audience have reflected upon the meaning of the profession which you are intending to follow, or of the duties which are associated with it? How many of you have in mind a clear-cut definition of the character of the mental processes used by experienced engineers in executing their duties? How many of you have a clear recognition of the distinctions of mind and method which compose the differences between an engineer and a well-educated mechanic of unusual skill? You must reflect on all of these points and come to adequate convictions before you can become of the ablest and most distinguished ranks of engineers. These things can be organized in one's mind only by the thoughtful reflection which arouses the imagination. Thoughtful reflection is, to paraphrase Lowell, as needful for the imagination as society is wholesome for the character; and an engineer's education can be scarcely begun until he learns that an exact and truthful imagination is one of his most important professional possessions.

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But we must also remember that a truly influential man must know something of literature, biography, history, art, and music. He must be a man of complete living. "To prepare us for complete living," Herbert Spencer said in his interesting book on educaiton, "is the function which education has to discharge; and the only rational mode of judging of any educational course is to judge in what degree it discharges such function." Spencer also defines what he means by complete living, and every able, reflecting man may give a similar definition out of his own consciousness and experience: An education for complete living includes training the faculties of self-preservation, the faculties of self-support, the faculties of the domestic life and proper parentage, the faculties of good citizenship including interest and activity in the betterment of our political and social relations. the faculties of properly enjoying one's leisure and lending enjoyment to others.

The study of science and its applications as carried on in the atmosphere of our better engineering schools may surely be made an impor-

tant stimulus to each of the powers and faculties which are required for complete living. It has been asserted that it lends itself more particularly to the earlier and less disinterested ones; but that this is necessary I must deny. The profession of the engineer demands a creative imagination cultivated to the sober clear sight which sees things as they are, and from which springs an appreciation of art, literature, and music which rivals that produced in any other manner. But the physical sciences and their applications, even when coupled with desirable dilettantism, are not adequate to the requirements of engineering in its broadest sense; and the political and social sciences must be added to the list.

In this latter respect most of our engineering curricula have been startlingly deficient. I even lay the charge at the door of your own great Institute; an Institute which has instructed the spirit of many who have become of the nation's leading engineers. Will you look through that list of distinguished engineers and tell me how many have become notable for activities in the political and social affairs of the nation? We can count to your credit your distinguished alumnus and President and a few others of corresponding public spirit, but they are few when noted in comparison with the importance of the engineer's work in civilization and civic life and the important influence which the Institute has borne in American engineering. Remember that the existence of civilization as we know it, and to a large degree its advancement, depend upon transportation and intercommunication, which are fundamentally engineering industries. Are the engineers then to allow those important political and civic activities which cling around civilized life to fall under the sole direction of others?

It is an easy answer to say that the engineers are too busy in working and directing the economic advances of civilization to afford attention to the way in which political and civic activities are guided; but this answer is inadequate. The lawyers, the physicians, the merchants are also busily engaged in affairs of importance, in their kind, and they might make a similar excuse for abstaining from political and social activity; in which case, I think we must all admit, our forms of government would soon break down from want of adequately trained and disinterested leaders.

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I take the ground that it is desirable for students as well as faculties to recognize, reflect on, and understand the human shortcomings of the courses of training. By no other means, it seems to me, can earnest students be stimulated to make the most of their opportunities and belie the charge of inefficiency that is sometimes laid at the door of engineer-

ing graduates. I think there is no doubt that the engineering courses make the best preparation for engineering and industrial life that has been devised. Good engineers lived before the engineering schools; but the engineering schools are doing a tremendous work in providing men with the mental means to extend engineering knowledge and advance engineering practice.

One of the things that students, to their disadvantage, commonly fail to keep constantly in mind is the fact that a man of ability and courage can usually make of himself that which his ambitions dictate. If you set your ambitions right there need be no fear of your reasonable success. Failure by a man of ability and courage, who also has the advantage of education, is scarcely to be condoned. The only sufficient excuse is an inadequate physique or ill health caused through no fault of the individual. In engineering nothing is ordinarily sufficient to excuse failure.

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If a man concentrates his efforts, is honest, is patient, performs his duties with thoroughness, masters the principles relating to his employment, and *thinks* (it is remarkable "How many never think, who think they do"), he is sure to succeed. True success is a great achievement, and great achievements require long expenditure of well-directed endeavor for their erection.

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ADDRESS TO THE GRADUATING CLASS OF THE SCHOOL OF ENGINEERING AT THE UNIVERSITY OF KANSAS.

By

Dr. J. A. L. Waddell.

This address was delivered in 1893 by one of the Editors and listened to by the other, who was then a student of K. U. No comment is permissible; but the reader's attention is called specially to the advice given to young graduate engineers to obtain a wide, general experience in comparatively low positions before settling down to one particular line of work. This experiment has been tried by a number of men and with great success.

Editors.

ADDRESS TO THE GRADUATING CLASS OF THE SCHOOL OF ENGINEERING AT THE UNIVERSITY OF KANSAS.

By

Dr. J. A. L. Waddell.

In an address like this, it is, I suppose, in order for me to give to you, who are about to undertake the duties of practical life, some good advice based upon my personal experience, which, by the way, covers about eighteen years of practice in various branches of engineering, including that of civil engineering education. Unfortunately, it is a fact that, in general, people are more fond of giving advice than of taking it; and I have found on a number of occasions that advice given to students was unheeded. It is an old saying that each one must "dree his ain weird," and there is a great deal of truth in it; nevertheless I have seen occasions when advice from older men was eagerly sought after and appreciated when given. To many minds the receiving of advice and acting upon it is an indication of mental inferiority, or at least of a lack of strong-mindedness; but I have noticed that the individuals who are governed by such ideas generally make a failure in both professional and business life. Self-reliance is a very good thing, if not carried too far, and, in fact, is an essential to success in any calling; nevertheless, its possession should not debar one from profiting by the experience of others.

I can look back to a portion of my life when some sound, practical advice from an older engineer would have been of the greatest benefit to me, in that it would have been the means of preventing me from wasting considerable valuable time, simply because I did not know how to employ it advantageously.

Let me hope, then, that my words to-day will not be entirely wasted, but that some of you will benefit by them, and that in the years to come I shall occasionally run across one of you who will tell me that my advice was good, and that it has proved useful to him.

Please remember that it is based upon my personal experience as well as upon observation of the careers of others, and that it is drawn from both successes and failure; because there is always a great deal to be learned about "how not to do it." Please remember, also, that I am in great sympathy with students of civil engineering; for at heart I am still a professor, and some day after I have earned sufficient money

in the practice of engineering to permit me to indulge in such extravagance, I should like again to occupy a professor's chair. To my mind there is no more useful or higher branch of the engineering profession than that of instruction, notwithstanding the openly avowed opinion of many practicing engineers to the contrary. It is not sufficient, though, to recognize for oneself the equality of professors and practicing engineers; but it is necessary to make the world at large acknowledge the fact. Steps in this direction, I am happy to say, are now being taken; and today the professor of civil engineering takes higher rank in the American Society of Civil Engineers than he did a few years ago.

But to return to the subject in hand, viz., advice to young engineers. On account of the kindly feeling I entertain toward all engineering students, especially those who are earnest and ambitious, I shall speak to you very freely and openly, giving you of the best that I have, even if by so doing I lay myself open to adverse criticism.

But to accomplish what I have in mind I must drop all formality in addressing you, and meet each of you as man to man upon a most intimate footing—in fact I must speak as if I had known each one of you for years and had taken a personal interest in your welfare. I shall take it for granted that you will permit this liberty, and shall govern myself accordingly. In following this method I shall have to reduce my address to a rambling discourse, ruining it perhaps as far as elegance is concerned, but at the same time rendering it the more useful.

As Commencement Day approaches, each engineering student of the graduating class, as soon as he has assured himself of his graduation, begins to think more and more of the work that he shall do after finishing his course of study, and of the position that he will obtain. He naturally gauges the positions that he hears of by the amount of salary offered in each case; and strives to obtain the one to which the highest salary is attached. In so doing he makes a fundamental and most serious mistake, because the true ultimate value of any position offered to a newly fledged engineer is an inverse function of the salary paid. This sounds, perhaps, like a very strange and wild statement, but it is, nevertheless, a true one;—let us look into the matter a little, and perhaps you will agree with me. The highest salary in this country paid to young engineers immediately after graduation is, as far as my experience goes, one hundred dollars per month; and this amount is given only in very flush times when there is a great demand for assistants in the field. To earn such a salary at the start, the young engineer must be already well posted on the practical part of the work in addition to being versed in the theory. Now what practical work is there on which students are posted?

Why, simply elementary surveying! Consequently the fortunate or unfortunate young man (according to the point of view of the person considering the case), who receives one hundred dollars per month to begin with, will have his attention confined to the laying out of town lots for speculators or to surveying farms; and how much, pray, is to be learned on that kind of work? Something, of course, because no one can do work of any kind without increasing the amount of his knowledge and experience; but how little it is in comparison with what is to be learned in the higher branches of engineering! Again, what future prospects are there in such work as surveying? It is seldom, indeed, that a surveyor makes more than a bare living, and when times are bad the young engineer engaged in this line is very likely to lose his position or have to spend many idle days without pay.

Railroading offers a better field to the recent graduate than does land surveying, and at the same time the pay is fair. For instance, any man on a railroad survey can really earn for his employers forty or fifty dollars per month besides the cost of his subsistence, even if it be only by dragging chain or driving stakes; because the life is a hard one physically, and manual labor can always command a certain amount of pecuniary compensation. But the young engineer who works in a subordinate position on a railroad survey will have to spend a great deal of time in a manner that is profitable to his employers, but not so profitable to himself. He will be gaining some experience, of course, but not the greatest possible amount or the highest grade of experience. Notwithstanding this, I believe there is no more attractive opening, and oftentimes no more truly profitable one, to the recent graduate than a position on a railroad survey. Coming as he does from a sedentary life, and too often worn out both physically and mentally by overwork, the active exercise in the field proves to be exactly what he needs; and after a few days, when the physical exhaustion attendant on unaccustomed bodily exercise has passed away, he feels like a new man, the mere acts of living and breathing become a pleasure, the sun appears to shine more brightly than it has shone for years, and he experiences a new phase of existence. Such a life is most seductive, and unless one is careful, it is apt to divert his tastes and ambitions from higher to lower things. The truly ambitious young man can, however, improve his time in such a position by picking up stray bits of knowledge here and there, not only on his work, but by conversation with the other members of the party.

An experience of this kind at the outset of one's career will give him a taste for out-of-door life which he will retain as long as he lives. On this point I speak from personal experience; for shortly after graduating I took a position on the Canadian Pacific Railway that caused me

to spend eighteen months in the wilderness to the northwest of Lake Superior, where, in addition to my strictly professional duties, I had to work harder physically than any day laborer in civilization. Now, strange to say, there is no portion of my professional career to which I look back with as much pleasure as I do to those eighteen months spent in the wilds. There is something peculiarly attractive and inspiriting in such a rough life, with its hard work, long tramps through the swamps in summer and on snow shoes in winter, its hardships, which include coarse and sometimes not overplentiful food, uncomfortable lodgings (generally consisting of a leaky tent carpeted with hemlock boughs to serve as a couch), innumerable insect pests, wet weather in summer and extreme cold in winter; its jolly evenings spent over the camp fire, where past experiences in bush-life are narrated, and even its dangers, which give spice to the whole life. Such dangers were by no means imaginary; as many a poor fellow has lost his life in that country through forest fire, severe cold (the temperature often passing below the freezing point of mercury), drowning by falling through the ice of early winter, or by the capsizing of a canoe; or worse still through being lost in the woods and perishing slowly from starvation.

This early experience of mine in railroading, together with still earlier experiences in camping out, gave me such a taste for bush life that even today I would rather spend one month in hunting and fishing among the Rocky Mountains than twelve months on a pleasure trip in Europe.

But to return to the question of compensation for services immediately after graduation. There are various lines of engineering where an inexperienced man can earn a living at office work, but the pay is necessarily small; because the work can be done by cheap draftsmen who are content to accept a small wage, and are in truth generally worth no more than they get. Such positions will eventually lead to something higher, but the young engineer will be compelled to do a great deal of drudgery in order to earn the money which his employer pays him. In any case, though, an engineer needs sufficient experience in drafting to enable him to learn how to put his ideas on paper rapidly, and how to make a presentable drawing, consequently such experience is beneficial; but one should avoid having too much of it, in order not to become a mere drafting machine.

But now let us suppose that our new alumnus enters the office of an engineer who is doing a large amount of practical work in one of the higher branches of engineering, what do you suppose his services are really worth to his employer? Candidly, except in most uncommon cases, they are worth absolutely nothing; yes, oftentimes less than noth-

ing, because not only has a great deal of his work to be done over again, but also his employer has to devote considerable time to his instruction in fundamental principles and practical methods, one day of which time is worth in dollars and cents more than a whole month of the young man's service. But see what the young man is gaining—not a day, not an hour passes without his learning a number of valuable principles, facts, and methods, so that at the end of a month he will have acquired a greater amount of valuable knowledge than he would have obtained in a year when working on a fair salary at routine work. In such an office the newcomer who has had no practical experience seldom receives any salary; and the time is not far distant when in this country an inexperienced young man will have to pay for the privilege of working in such an office. This has been the custom for many years in England, but it is a custom that has been abused by the employers, who have thus brought the system of apprenticeship into ill repute.

And now have I said enough to convince you of the correctness of my statement that "the true ultimate value of any position offered to the newly fledged engineer is an inverse function of the salary paid"? I shall leave each one of you to answer this question for himself, after thinking over at his leisure what I have said on the subject.

Now let us take up the question which each of you has undoubtedly propounded to himself many times of late, viz., "What branch of engineering shall I adopt as my life's work?" You have found it a difficult one to answer—have you not? I do not see how it could well be otherwise; for you have as yet had very little opportunity to see what the various branches of the profession are like, and of what their work consists. Some of you may be able to answer the question to-day to your satisfaction, or at least you may think you can, but the majority of you have been unable to make up your minds. In my opinion, it is not advisable for you to try to do so at present. This is no time for you to choose a specialty; and even if you do choose one, you ought not to settle down now to practice it to the exclusion of all other work. The old definition of an engineer, viz., "a man who knows a great deal about something, and something about everything," was not a bad one, and still holds good even in these days of specialties. There is no branch of engineering that is separate and distinct from all other branches, consequently the more general the experience obtained in youth, the greater will be a man's capacity and the broader his mental grasp during his best working years. On this account I would advise all of you who can afford to do so, to spend a few months, or at most a year, on one class of work, mastering as many details as possible, then drop it and take up another branch, and so on until you have obtained

a wide, comprehensive, and thorough experience in general engineering. Meanwhile, make up your mind as to what specialty you will choose, or at least as to what line of engineering you will follow; and as soon as you have decided finally, let your studies and practice tend continually more and more toward that chosen line, until eventually you abandon all others for it and make it your life's work. Be content for a while to earn a bare living, provided that you are obtaining the experience you desire. If you do this, take my word for it, you will find that at middle life you will outrank, professionally, those who started in with you but who adopted the policy of confining themselves to one line of work and thought, thus rendering themselves men of one idea or rather one set of ideas.

Some of you, perhaps, on account of pecuniary obligations, contracted in obtaining your education, or family responsibilities, cannot take this advice; but will have from force of circumstances to settle down in one place with the object of earning as quickly as possible an income that will suffice to pay off your indebtedness or maintain your family. If there be any of you so situated, I would urge upon you the importance of extensive technical reading in other branches of the profession than the one in which you engage, in order that you may prevent yourselves from becoming fossilized and incapable of taking interest in anything outside of your special line of work.

To all of you I would say, "Don't leave school with the idea that you have completed your technical education; for, no matter how thorough your course may have been, your technical education has merely begun." It is true that you have had enough book learning to enable you to earn a living without further study, but you can never attain professional distinction without continuing your studies. I recognize the fact that it is quite difficult to carry on a course of technical reading when one has to work long hours in either the office or the field, but I have proved by personal experience that it is practicable. The method that I adopted was to take a certain treatise, mathematical or otherwise, and arrange to read it through thoroughly and understandingly in a certain number of days, laying out beforehand the amount of each day's reading, and basing it upon the average time that I had to spare and the character of the book. If for any reason I failed to complete the reading allotted for any day, I read an extra amount the next day, and sometimes read ahead of my allowance so as to anticipate possible interference with my plans. In this way I accomplished the entire reading in the allotted time; and it paid. It is a good practice to carry in one's pocket some technical book to read at odd moments, for instance, during the noon hour in the field or while waiting for a railway train or even while traveling on the cars, although

I cannot really commend the latter practice because of its injurious effect upon the eyes.

It is essential that you read the principal technical newspapers and periodicals in order to keep abreast of the times, also the transactions of the leading engineering societies, especially those papers therein which treat of subjects allied to your line of work. There is one point on which I wish to caution you, viz., that an article is not necessarily valuable because it is composed wholly or partially of mathematics. As a rule, most of the mathematical papers on engineering subjects that one runs across are mere rubbish; but occasionally a really good mathematical engineering paper appears; and this ought to be read. After a little experience you will find no difficulty in sifting the wheat from the chaff. Do not misunderstand me in this matter of mathematics, for I would be the last one to advocate abandoning the study of that science after graduation. I merely wish to warn you against wasting valuable time on investigations which are too often based on false assumptions, or that treat of matters which could be settled more simply in some other manner.

In determining upon a course of reading, one should not confine himself entirely to technical books and papers, but should choose some standard literary works for the purpose of improving his style in writing; for, alas! it must be confessed that most writers on engineerng subjects have a great deal to learn concerning correct literary style.

In my opinion, it is the duty of each member of the engineering profession to add his mite to engineering literature; although one should never write a book or paper merely for the sake of producing something. The most valuable information that the profession possesses is to be found in papers published by engineering societies, and describing works completed, the difficulties encountered during construction, and the methods adopted for doing the work. Each of these papers, together with the discussion evoked by them, not only marks a step in constructive progress, but also indicates how the next steps should be taken. Abstract papers or those of a generalizing nature are also of the greatest value; but there are only a few men who are competent to prepare such papers, consequently their number should be limited. It takes a bold man to write such a paper; and he is likely to get into trouble because of it, hence I should advise you to confine your literary efforts to descriptions of work done or the treatment of minor details until your experience has accumulated sufficiently to warrant you in an endeavor to generalize.

In preparing engineering papers, cultivate a clear, terse, and concise literary style, so as to express your ideas in the fewest words consistent with a due consideration for fluency and elegance of diction.

Cut out all padding from your writings, because engineers are too busy to spare time to read anything that is unnecessary. The proper age at which to commence writing technical papers is not easy to fix, but in general it is safe to advise that one's early efforts be presented to minor or local engineering societies; then if these be well received, future papers may be presented to the engineering periodicals or to the national engineering societies. There is nothing which a young engineer can do that will advance his professional standing so much as the writing of a good, sound technical article for publication; and there is nothing that he can do which is more detrimental to his reputation than to write an incorrect or weak one. When contemplating the writing of a paper, it is a good plan to ask one's self these questions: "Is this paper really needed?" "Will it fill a gap?" and "Will it prove useful to the profession?" If the answers be in the affirmative, write the paper; if not, don't.

As for the writing of a technical book, better postpone such work until you have had at least eight or ten years' experience; and do not even then undertake it, unless you see that there is a need for such a treatise as you contemplate writing, and that you have exactly the right information to present to the profession.

While it is true that there are a great many technical books published which should never have been written, it is equally true that technical literature is far behind engineering practice, and that there never was a time when sound engineering treatises, prepared by thoroughly posted, practical, and educated writers, were as much needed as they are to-day. You see, therefore, that for those of you who have literary tastes and tendencies, there is plenty of occupation ahead. Unfortunately, there is no money to be gained directly in such work; but on the other hand there is reputation to be made, and that means eventually money, although, it is a mistake to connect the two at all closely even in one's thoughts. Professional reputation in itself ought to be sufficient incentive for a young engineer of the right sort; but the fact that the obtaining of it will ensure pecuniary success is undoubtedly an extra stimulus to exertion.

Let me advise you to pay special attention to the study of specifications and contracts for engineering works, and to learn how to prepare them for yourselves. You can learn readily the style of such documents, but it takes years of experience to enable one to prepare them so that they shall cover the entire ground in a perfectly satisfactory manner. The more experienced an engineer the more thorough will be the specifications that he writes; but from this it does not follow that in comparing specifications prepared by two engineers their values will vary di-

rectly as the amounts of experience of the writers; because some engineers seem to be unable ever to learn to write good specifications. This is due to a want of literary training in their early education; and a most deplorable and grievous fault it is.

Post yourselves on legal decisions of interest to engineers, and let some of your miscellaneous reading include the laws of contracts.

Study business methods as much as possible, and learn how accounts should be kept. These things are important, and they need not demand very much time; because with all the mental training you have had, and will have in your practice, you ought to grasp readily all such comparatively simple matters. A good way to master them is to consult with men of business, bookkeepers, etc., with whom your work throws you in contact. They can show you often in a few minutes what might take you hours to study out by yourselves.

And here let me give you a little piece of sound advice. Never be too proud to learn from the most ignorant. Even the navvy who handles a pick and shovel can give a young engineer valuable information concerning earthwork; and the stonecutter and quarryman will generally be found well posted on many matters of importance in masonry construction that are not treated in the text books.

Whenever you have an opportunity, study how to manage men, and how to get the greatest amount of useful work out of the workmen. A little tact will often accomplish results that could not be obtained in any other way than by its use. While it is necessary to be firm in dealing with workmen, and in fact with all employees, it is well to treat them reasonably and not to lay down the law too severely. The better the understanding between employer and employees, the greater will be the amount of work accomplished.

Post yourselves concerning the money values of all kinds of engineering construction; nothing gives the general public more confidence in an engineer's ability than to perceive that he is well versed in the cost of all kinds of work.

Immediately after graduating each one of you should enter the American Society of Civil Engineers as a Junior, and should get his grade advanced to that of Associate Member, and finally to that of Member, as soon as he can qualify. As a member of any grade in that Society you have the right to take part in the discussion of any paper, and to present to the Board of Direction for acceptance any paper of your own. You are also entitled to receive the *Transactions* of the Society and to attend all of its meetings.

If you are stationed for any length of time in any city where there is a local engineering society, it will pay you to join it, and to take as

active a part in the proceedings as your practical experience will warrant.

You will find that all through life it will pay you to make for future reference systematic notes concerning not only your own work, but also that of others; but to be of any practical value these notes should be transferred from time to time to an index book, so that any particular subject can at any time be found without delay. It is very important to know where to look for any required published information, and for this the various indices which have recently been issued will be found valuable.

After finishing any large piece of work, and while it is still fresh in your mind, it is well to write out an epitome of knowledge gained on it, indicating the methods used, improvements to be made in them on future work of a similar character, mistakes to be avoided, etc., then have a number of copies of this struck off on a typewriter to keep for future reference for yourself and perhaps for others.

In my practice I have found it very convenient to carry in the pocket a note book for recording "things to be done," so that whenever a new idea strikes me, or when I think of something that I wish to do, I make a note of it on a list; and whenever I finish doing anything so recorded I draw a line through the item. When the list becomes too much erased, I prepare a new one by collecting the items that have not been crossed out. By the use of such a list I find that I can accomplish a great deal more than I could had I nothing but my memory to rely upon; for when I have an idle minute, which, by the way, is not very often, I pull out my note book and see what there is that I can do. I would suggest that you give this method a fair trial.

Some engineers believe in keeping a diary. I do theoretically—but practically I have failed to keep one, although sometimes I wish I could remember what I was doing on a certain day, and cannot. It would be well to give the diary a trial also.

You will find as you go through life that earnestness of purpose is the main-spring of success, and that if you set your mind on attaining any object within reason, you will, if you keep on trying, eventually succeed in attaining it. I am a firm believer in the French proverb *"Tout vient à celui qui sait attendre,"* because I have tested it, and have never yet found it fail to be correct.

In all your work develop and employ constantly such a perfect system of checking and counter-checking as will render you as nearly absolutely proof against making mistakes as it is possible for fallible humanity to become. By so doing you will save yourselves infinite worry and trouble. I know of no more unpleasant sensation than that which one

experiences immediately after ascertaining that he has made a blunder; and, moreover, the sensation does not pass away as quickly as one might wish. I have known cases in which the duration extended over years.

Do not be discouraged by failure, but endeavor to profit by it; and do not be afraid to tell brother engineers of your failures. It will do you no harm, and may do them good. It takes a brave man to acknowledge a mistake or a failure, but a man who is deficient in that kind of courage would do well to keep out of the engineering profession. Mistakes of both oneself and assistants are the *bête noire* of a conscientious engineer, but I find that the longer one is in practice the fewer mistakes will escape his observation.

Become acquainted with as many engineers as possible, and try to establish yourselves on such a friendly footing with a few prominent members of the profession that you can occasionally go to them for advice. It is a fact that if an engineer of established reputation takes a personal interest in any bright, active, energetic, and ambitious young engineer, he can be of the greatest assistance to him, and can help him to advance with almost phenomenal rapidity in the profession.

Should you desire at any time to obtain some general knowledge that cannot be found in print, do not hesitate to ask other engineers for it. The chances are that it will be given to you most cordially; for any professional man of the right stamp is always glad to help a brother engineer with advice and to give him the benefit of his greater experience. It may happen occasionally, though, that you will be snubbed. Unfortunately, one cannot make such a sweeping statement concerning engineers as it is customary to make concerning sportsmen, viz., that "all sportsmen are good fellows." I will say this, however, that as far as my personal experience is concerned "most engineers are good fellows," and I think you will find that there is less jealousy and more good fellowship among engineers than among the members of any other profession.

It is hardly necessary for me to touch upon the converse of this, viz., that you should be ever ready to aid a brother engineer in every way that lies in your power.

Avoid all petty professional jealousies, and remember that to rise in the world it is not necessary to push others down. If it were for no other reason than mere policy, it is generally better to say a good word for another engineer than to speak against him; but this is no reason for one's stultifying himself when asked if he can recommend for a position someone of whom he does not approve. It is too often the case that when an engineer is discharging an employee for whom he has no use, he gives him a written general recommendation, merely for the sake

of parting pleasantly. This is a mistaken policy; because it tends to detract from the value of all written recommendations.

Assistants on engineering work may be divided into two classes, those who work for the almighty dollar, and those who, as it is termed, work for glory. Those of the first class adhere to certain fixed hours, and as soon as quitting time comes, or a little before, they get ready to stop work for the day. Moreover they always appear afraid of doing too much for their money. They reach the climax of their career when they obtain a position worth about five dollars per day. Those of the second class work more for the knowledge and experience to be obtained than for the salary, and seem to pay but little attention to office hours, continuing their labors far into the night when interested in what they are doing, or when there is any necessity for extra exertion. Such men rise steadily and often rapidly to responsible, well-paid positions; and the less they say about increase of salary the oftener it appears to be raised. It is unnecessary for me to advise you as to which of these classes you should join.

Of course there are times in a man's professional career when it may be advisable for him to assert himself and demand proper compensation for his services, if he thinks that they are not adequately remunerated; but this should not be during the first few years of his practice, when he is in reality serving his apprenticeship. Later on, especially after marriage, when the welfare and comfort of wife and children depend upon the amount of his earnings, it becomes a man's duty to look out for the dollars.

And this brings me to another point upon which I desire to touch, as it is an important one, viz., the best age for an engineer to marry. The young man who immediately after graduating rushes blindly into matrimony, regardless of how it will affect his professional career, makes a serious mistake; for the care of a family will prevent him from going from one class of work to another in order to obtain a varied experience, and will tie him hand and foot, necessitating his grinding day after day on work that perhaps he detests, and on which there is nothing more to learn, because the dear ones at home are dependent upon his daily earnings. If circumstances permit, it is well for the young engineer to wait until he is twenty-eight or thirty years old before he puts on the matrimonial yoke, but it is not advisable to delay much longer than this, if he intends ever to marry at all; because the longer he waits the more set in his ways will he become, which condition, as we all know, is not compatible with the principles of American home rule.

Let me take the liberty of advising you to endeavor always to save a portion of your earnings and to invest it in some good security

which will bring you in a fair rate of interest. Any investment which promises more than six or eight per cent. should be looked upon with suspicion; for while one such scheme succeeds, three others will fail. You may consider me an authority on this point, as my experience is personal and has been paid for. It may be difficult to save money when one is traveling from place to place obtaining his professional training in the manner which I have suggested; but still it is practicable, even if the amount be as small as five or ten dollars a month. Here, too, I am speaking from experience, because as a young man I spent practically all I earned, and the time came when I wished that I had been more economical. After marriage you will find that this matter of saving money becomes an absolute necessity, so why not begin it at once? Remember that I do not advise niggardliness nor parsimony; for such attributes are incompatible with American manhood; but on the other hand extravagance is unnecessary and uncalled for.

I should like to call to your attention a series of papers and discussions on the subject of "engineering ethics" which the technical press has been publishing lately. The importance of this subject cannot be over-estimated. The engineering profession needs a code of ethics in order to raise itself in the public opinion to the position it ought to occupy. I fear it is going to take time to establish such a code; but the day will surely come when we shall have one; and then our profession will be recognized as the highest of all, in that it takes the lead in the progress and development of the entire civilized world. Until this code be established, there is nothing for each of us to do except to have a little code for himself, consisting of a single principle, viz., "Do the square deal by everybody under all circumstances." At times it may be difficult to decide as to what is exactly the best thing to do; but, if one uses his judgment and endeavors to put himself mentally in the other man's place, his decision cannot be far from right.

The engineer in charge of construction stands in a peculiar relation to both his employers and the contractors; and the true relation is not generally recognized. It is that of arbitrator, and not that of oppressor. No one who employs an engineer has a right to think that he purchases that engineer's conscience when he pays him his salary. It is as much an engineer's business to look out carefully for the rights of the contractor as it is to see that his employers receive the full value of what they pay for, and that all work is properly done. Believe me, no engineer ever yet made a success professionally by oppressing contractors. I consider it the engineer's duty to aid the contractor in every legitimate manner, and to save him expense whenever it is possible to do so properly. Unless a contractor be satisfied with the profit he is making out of

a piece of work, the chances are that he will slight it. In letting work it never pays to award the contract to any competitor for less than actual cost plus a living profit. The older an engineer grows, the more convinced will he become of the correctness of this statement.

Let me call your attention to the importance of systematizing your work. The most successful engineer is he who can obtain the greatest amount of correct work out of those whom he employs, and it is only by looking ahead and laying out systematically the work of each individual and of the entire corps that this can be effected.

Let me counsel each one of you to set for himself sooner or later an ultimate object to be accomplished, and let it be a great one, but still well within the realms of possibility; and let him ever strive toward its attainment. If he succeed, he will be well repaid by the satisfaction of feeling that he has done some material good for his fellow mortals; but if not, he will still feel that he has done his best, and that his life has not been spent in vain.

But after all, there are many important things in life for you other than professional advancement and success; although you may judge from my discourse that I have forgotten this, or that I do not even recognize it. Believe me, I would by no means counsel you to neglect the many social and other pleasures that are within your reach. It is bad policy to reduce one's self to a mere working machine; and if you do, you will be sure to find that the machine is likely to break down or to run badly for want of a little lubrication. Every hard working man is entitled to an occasional holiday; and to do him the most good he ought to spend it in the manner which will afford him the most enjoyment. In the end, no time is lost; because the reviving effect of the vacation will enable him to work all the harder when he settles down to business once more.

Again, a man has certain obligations toward his fellow men; and one of the most important is that he make himself agreeable and entertaining when in company. This he cannot often do, if he be a mere drudge and a slave to his occupation.

In the rapid development of humanity which is taking place at the present time, it is necessary that each individual take a deep and absorbing interest in one certain subject; but it is equally important that the people as a whole concern themselves with a variety of subjects, thus necessitating that each individual have a number of topics in which he takes at least a passing interest.

Unless such were the case, the whole mass of humanity would be working without any coherent purpose, each unit being independent of

all the others, and following a path of its own regardless of how that path interferes with those of the other units.

A professional man is liable, on account of the intense interest he feels in his work, to overlook these facts; and it is on this account that I make a point of advising each of you to mix as much as possible with his fellows, and to endeavor to make himself appreciated by them as something more than simply a hard-working engineer.

LAST WORDS TO THE CIVIL ENGINEERING SENIORS.

By

Dr. Ira O. Baker.

The kindly advice given by Dr. Baker to his young friends who were about to lose his guiding care is of extremely great importance and value. It is as good and sound to-day as when it was offered in 1894; hence it is to be hoped that the readers of this compilation of addresses will derive much benefit from Dr. Baker's wise and friendly words.

Editors.

LAST WORDS TO THE CIVIL ENGINEERING SENIORS.

By

Dr. Ira O. Baker.

Address to the Civil Engineering Club, University of Illinois, June 11, 1894.

When the program committee asked me if I would present something here this morning, I immediately thought that perhaps I might use the opportunity for a few final words with our graduating members. Frequently the circumstances and conditions under which anything is said give it an attention and weight which it would not otherwise have.

When the traveler through an unknown country comes to the brow of a hill, if he is wise he surveys the landscape, selects an objective point ahead, decides upon his path through the valley below, and then proceeds step by step to find his way down the hill, through the valley, and up on the other side. Obviously the time to decide upon the path through the valley is when we are upon the hill top, and we are more sure to reach the goal by the shortest route if we keep our eye steadily fixed upon our mark ahead.

You, members of the graduating class, are upon a hill top this morning. You are shortly to break off old relations and enter upon new ones. Let us see if we can find a worthy objective point ahead which shall serve as a help and inspiration while you wend your way through the valley.

I am fully aware that this is the last time that I shall ever address you in the relations of teacher and taught, and it is with mixed feelings of regret and pleasure, of solicitude and anticipation that I bid you adieu; and I fain would reveal to you some of the feeling that a teacher has when he sends his boys out into the world to test their powers—and his. But the occasion demands a higher motive than merely personal pleasure, so I ask your kind indulgence while I try to teach one more lesson. I make this attempt knowing that the occasion and your thoughts will more clearly reveal to you the truth I wish to teach than can my words.

It is not necessary to remind you that recitations are ended; but I do want to urge upon you that you do not cease to be a student. Whatever the kind and stress of your occupation, keep a little time for study and reading. If your work here has been well done, you have barely

reached that point where you are able to gain knowledge by self-directed effort. You will doubtless have many painful illustrations that you do not know it all, but your daily work will compel study of the practical details of your business. You will be compelled to get these matters, or you will not get work. I expect you to succeed reasonably well in these particulars; but I desire to urge upon you that you continue to grow, to expand, to increase your powers. You ought always to have in hand some subject upon which you are doing thoroughly downright hard study. Such a course is absolutely necessary for intellectual vigor and activity. In the next few years you ought to study professional subjects as a matter of course, but you ought also to broaden your education and extend your horizon by the study of scientific and literary and historical subjects. I have time only to assert this point, not to prove it.

Undoubtedly you will be tempted to say that you haven't time for such study, but I say you must make the time. If I had time I should like to illustrate this by giving you some of the particulars of the lives of Gladstone, and Garfield, and Lincoln, whose labors and cares were simply prodigious; and yet they found time for an astonishingly wide range of reading and study. To make this matter definite, let me urge that you regularly and conscientiously give one-half hour each day to the study of some subject which will broaden your knowledge and extend your horizon.

The world moves. New problems are continually arising which must be solved. The state and the nation have been very liberal to you, and have a right to demand that you shall meet these new obligations when they arise. You are expected to find new and better solutions to old problems, and to lead us into unexplored and undiscovered fields. You have given to you five talents. Will you lay them away in a napkin, or will you use them and gain five other talents?

By all means do not fail to cultivate the ability to write and speak your mother tongue correctly, forcibly, and even elegantly. Even an engineer has frequent use for this power, and his ability as an engineer is continually being judged by his written and spoken language. Eads is not infrequently ranked as the leading American engineer, but his reputation as an engineer is due as much to his ability in writing and speaking as to his knowledge of engineering.

One precaution: Do not become a man of books to the exclusion of affairs. Society is all the time struggling with industrial questions, social reforms, and political problems which you, having received your education as a gift from the state, should help to solve. I have only time to hint this.

In one respect your free education is liable to do you harm. You have received information more cheaply in the past than you ever can in the future. Do not be afraid to spend your money in travel to see things and men. There is a wonderful stimulus in whetting against other men, particularly those engaged in the same business as yourself. Do not fail to use travel as a means of continuing your education. Remember that there is a scattering abroad that increaseth and a withholding that impoverisheth.

Allow me to offer a few hints to guide you in your intercourse with your professional associates.

1. Be patient and don't try to get on too fast. You may be over estimating your own abilities. It takes all summer to ripen the best apples.

2. Be liberal in the measure of your work. Don't even think of excusing yourself from doing what you reasonably can, by saying that you are doing as much as you are paid for. As long as you hold the position and accept the pay, do good, honest, faithful work. If the labor demanded is too great, make a courteous, frank, straightforward protest, or offer your resignation.

3. Be courteous and generous to your subordinates. In this matter let the golden rule guide your action. One of the ways in which this rule is violated is in passing judgment upon the works of others, in the way of fault-finding and belittling them, picking flaws, making small criticisms of design and method. Does any engineer imagine he raises himself in the opinion of others by so doing, or in any way advances his own prospects of success? Criticism for the purpose of suggesting improvements is a good thing, but criticism for any other purpose is unworthy a true man. The world on the whole is fair in its estimate of men; it recognizes the generous everywhere, and is just as sure to condemn the opposite.

4. Guard as carefully as life itself a high standard of professional honor and integrity:—whatever the measure of your professional success,—whether wealth and reputation crown your career, or disappointment and poverty be your constant and unwelcome companions,—let no taint of suspicion attach to any professional act or utterance. As young engineers you are nearly certain to have some severe trials in this matter. In his relations with contractors, in his recommendation of patented or special devices, in preparing reports that may influence the markets, the engineer is liable to have his judgment warped by subtle and corrupting influences. You will save yourself much annoyance and possibly some danger, if you will at all times maintain a character of unquestionable integrity. It should not be difficult for the conscientious

engineer, jealous of his professional honor, to decide what is right and what is wrong.

Now I think I can show you an objective point ahead by means of which you shall be able to find a way of safety and honor through the darkest valley of trial and temptation. I ask, then, what is your highest aim as engineers? Is it to stand at the head of your profession, and secure wealth and honor? Or is it scrupulously, conscientiously, and faithfully to discharge the duties of the positions in which you are placed? If it is the former, then you have many chances of failure to one of success, for such success will often depend upon circumstances entirely beyond your control. If your highest ambition is conscientiously and faithfully to discharge the duties of your position, then success depends upon yourself, for it is assured by simple and constant attention to the requirements of each occasion as it arises.

Ability, wealth, position, are all excellent things to possess. They mean, or may be made to mean, influence, weight, and power; but they are not the things which determine the essential value of a man. The true worth is measured by his character; not by his abilities, not by his positions, not by his successes, but by what he himself is.

We may all reach this most perfect manhood by simply doing all our work under the fullest appreciation of the meaning of that one word duty. That you may all through your life be actuated by this high motive, is my earnest petition.

THE ENGINEER AS A PROFESSIONAL MAN.

By

Dr. Nelson Peter Lewis.

The dicta of any man who has risen to high rank in the engineering world ought to command the attention and respect of all technical students and young engineers; hence the opinions expressed herein by Dr. Lewis, who has advanced gradually in America's metropolis to the exalted position of Chief Engineer of the Board of Estimates and Apportionment, ought to receive deep consideration from our readers.

This address was delivered in 1910 at the Annual Commencement of the Thomas S. Clarkson Memorial School of Technology.

Dr. Lewis was born at Red Hook, N. Y., February 1, 1856. He was educated at Red Hook Academy, St. Stephens College (A. B. 1875), and the Rensselaer Polytechnic Institute (C. E. 1879). In 1911 St. Stephens College conferred upon him the honorary degree of LL. D.

From 1879 till 1884 Dr. Lewis was engaged on railway work in Colorado and Louisiana; from 1884 to 1886 he was on the engineering staff of the City of Brooklyn, employed on the extension of the city's water supply; from 1886 to 1889 he was with the Central Railway Company of Georgia on location, construction, and maintenance; and in 1889 he returned to Brooklyn where he engaged in various branches of municipal work. From 1894 till 1902 he was chief of the Bureau of Highways of the City and Borough of Brooklyn; and from 1902 to the present time he has been Chief Engineer of the Board of Estimates and Apportionment of New York City, the duties of his position covering the entire field of municipal engineering.

He has served on a number of important municipal commissions and international congresses; and he was once sent to Europe to make a special study of the care and disposal of underground structures.

He is the author of numerous addresses, papers, and reports, relating particularly to highway improvement and city planning.

He is a trustee of the Polytechnic Institute of Brooklyn, and a member of the American Society of Civil Engineers and of a number of important technical organizations centering in New York City; and in four of these he has held the office of President.

Editors.

THE ENGINEER AS A PROFESSIONAL MAN.

By

Dr. Nelson Peter Lewis.

If the importance of a profession is to be judged by the number of those engaged in or preparing for it, by the number of institutions offering courses leading to it, or by increase in the facilities and equipment needed for giving such courses, it would not be extravagant to say that the engineering profession in its several branches has lately assumed the first rank in this country. It is realized that the development of our material resources is dependent in a large degree upon engineers or upon men with engineering training. A quarter of a century ago it is probable that a majority of the graduates of our engineering schools looked for their first practical experience to the work of railway construction, or that incidental thereto, which was very active at that time and which reached its climax in 1887, with a record of 12,878 miles of steam railway built during that year. The country having become fairly well supplied with railways, and the products of field, forest, and mine having been brought within reach of the consumer, the shipper, and the manufacturer, there succeeded an era of internal development, of betterment, of reclamation, and of conservation which is now well under way and which will doubtless continue for many years. The development of power, its conversion and transmission; increased facilities for transportation; the reclamation of arid lands through irrigation involving great impounding reservoirs and distributing ditches; the improvement of existing and the construction of new waterways; the development of our mineral resources; the creation of manufacturing plants and of great railway and shipping terminals; the increasing use of steel and concrete in building construction,—offer splendid opportunities for the engineer. There has lately been a marked tendency among all civilized people to concentrate in cities, a tendency which has caused surprise and which to many appears somewhat alarming. We are inclined to think of this tendency as especially noticeable in the United States, but such is not the case. On the other hand, it is a world movement. A comparison of the growth from 1889 to 1900 of six German and six American cities shows surprising results. The cities of each country were selected at random, and the population of each pair was about the same in 1880.

They are: Cincinnati and Breslau, Buffalo and Cologne, New Orleans and Dresden, Louisville and Hanover, Providence and Nuremberg, Rochester and Chemnitz. Not only has the German city in every instance increased more rapidly than the American city of the same size in 1880, but the lowest excess in the rate of increase is found to have been 23% in the gain of Cologne over that of Buffalo, while in two instances the increase in population of the German city has been 140% greater than that of the corresponding American city, namely, that of Dresden over New Orleans, and of Nuremberg over Providence.

While this increase in the population of the German cities has been most remarkable, the same tendency will be found throughout all Europe, in Moscow and Warsaw, in Vienna and Buda Pest, in Rome and Naples, in Marseilles and Lyons, in Brussels and Antwerp, in Rotterdam and Amsterdam, in Birmingham, Manchester, Glasgow, and Belfast; while in the New World to the south of us we see the same thing in Mexico, Rio Janerio, and Buenos Ayres.

Reference has been made to the anxiety manifested in some quarters of this concentration of population in large cities. It is often pointed out that many, if not most, of the conspicuously successful men have come from the farms, and the cry has gone out—"Back to the farms if we would save our civilization." It is true that a large proportion of our successful men have come from the farms, but it is in the great cities that they have found the opportunities of which they have been able to avail themselves by reason of the habits of industry, frugality, and self denial which they learned on the farms. Many of these men, after having attained success, are going back to their old homes with a new realization of their responsibility to their fellows. Better facilities for communication with centres of population, the distribution of scientific information concerning improved methods of agriculture, the general use of the telephone and the automobile, are greatly improving the conditions in the rural districts, but there will be no abatement of the growth of the cities. It is there that the great social and economic problems of the age must be worked out, and from them will emanate the uplifting influences which will make the world better.

The solution of the physical problems presented by this great urban development will call for the highest skill and the most intelligent effort of the engineer. Who is to give our cities the physical aspect which will correspond with the important part they are to play in the national life? The architect who will design buildings, giving them beauty and dignity? Yes, but before him must come the engineer who will create such a plan that the buildings of the architect may be

seen to advantage. What would Washington have been without its L'Enfant, Paris without its Haussmann?

Who is to make our cities healthful, our brothers of the medical profession? They will combat disease and relieve suffering, but public health depends not upon the physician, but upon the man who is responsible for a pure and wholesome water supply, for an adequate system of drainage, and for such care, disposition, or treatment of the wastes of a city that they will not menace the health of its own people or of those of other cities. Comfort and decency depend upon the proper cleansing of streets and disposal of household wastes without unnecessary offense. It was once thought that anyone with fair executive ability and the proper political affiliations could satisfactorily do work of this kind, but the people who pay taxes and expect results are no longer satisfied with such an arrangement. The disposition or destruction of wastes now calls for expert knowledge, and more and more we find technically trained men entrusted with such work.

The people of our great cities must be taught the duty they owe to the state, the municipality, and their fellows, and there are many great preachers and teachers to show them this duty both by precept and example. But will the people listen and profit by this teaching when they return to homes in narrow, dark streets, to squalid tenements where human beings are herded together in such a manner that decent living and intelligent citizenship are well nigh impossible? The gospel of light and air, of sanitary housing and clean streets will be more effective with the denizens of the slums than any other kind of preaching.

No human being can be healthy and moral if he has not some opportunity for recreation. Parks and playgrounds are therefore necessary. You may say that this involves simply a selection of park areas and a sufficient expenditure for their acquisition and improvement. True, if our parks are to be laid out in that way our choice will be restricted to such sites as are available, while in order to supply breathing spaces in densely built up sections, valuable improvements must be destroyed at enormous expense. Suppose, on the other hand, our park reservations are included in the original city plan with due regard for their natural beauty and their accessibility, how much more satisfactorily will be the result and how much expense will be saved!

Our cities require ease of transportation by horse-drawn or self-propelled vehicles and by railways. If the city is a port, provision must be made for such adequate wharves and piers with railroad connections as will attract and retain commerce. Not only the planning and construction of these various improvements that go to make up

the modern city, but the administration of the departments and bureaus controlling them are becoming more and more completely delegated to the engineer. A former Mayor of the City of New York in testifying before a legislative committee made the statement that if he were to be confined in his selection of heads of Departments to men who could assume their duties and be prepared at once to administer the work of the several Departments efficiently, without devoting a considerable part of their term of office to learning what was expected of them, he would be obliged in a large proportion of cases to name civil engineers.

It needs no argument beyond a mere recital of the facts to show that abundant opportunities await men of technical training who will rise to the occasion.

What sort of training is best calculated to produce engineers who will be capable of assuming and satisfactorily performing the various duties which have been hinted at rather than enumerated? There are characteristics which are sometimes due to very early training or even to heredity, while they also may be acquired or developed through collegiate education. It is difficult to name those which are of peculiar value to the engineer and which should be the special objects of his training, but there are some to which particular importance may be attached, and among these I would lay special emphasis upon the following:

Industry, intelligent application, accuracy both in work and expression, self reliance, tactfulness, integrity.

These are all qualities which every professional man hopes to possess or acquire. Not one of them will he consider unimportant or even non-essential, but combined they spell success,—they are a guarantee of achievement. For their attainment the ordinary course in college or technical school will not suffice. Some of them are to be acquired only in the harder school of life and through intimate contact with one's fellows. But let us be somewhat more precise in our definitions and take the time to consider what each one of them means and to realize its importance. The necessity of industry is so important that it is scarcely worthy of emphasis. No success can be achieved without it. The world's prizes do not go to the drones and the laggards, but to those who devote their best energies and abilities to the tasks before them, whether they be great and calculated to arouse enthusiasm or apparently unimportant and suggest drudgery.

A fair degree of industry is essential successfully to complete the course in a modern engineering school. Without it the student knows that he cannot secure the coveted degree, but when the young graduate gets his first position it will soon be apparent whether or not he is in-

dustrious from habit. If he is content to render the least service possible to enable him to secure his monthly salary check, he is not industrious; it will not take his employer long to discover the fact, and his promotion will be slow. It is not quixotic to say that a young man should consider that day ill spent in which he has not rendered to his employer service of a value greater than the pay which he is to receive.

But mere dogged application will not lead to the greatest success unless combined with intelligent application, which is nothing more nor less than industry guided by good judgment and aided by a sense of proportion or perspective.

To fritter away one's time and exhaust one's energies over unimportant details that a subordinate can do just as well, is neither wise nor commendable. Do not interpret this as encouragement of indifference to minor details. Every young engineer at the beginning of his career must expect to do his full share of seemingly trivial things, but when the time comes for him to assume greater responsibilities he should look at them in a broader way. This does not mean that the accuracy of the work of subordinates should be taken for granted, but there are other ways of determining this than doing it all over again one's self. When the accuracy and reliability of subordinates have been demonstrated, their results can be accepted as the foundation upon which more important conclusions may be predicated.

There are emergencies when concentrated effort continued through day and night almost to the point of exhaustion are required to accomplish important results, and the resiliency of youth is such that a moderate rest will restore the faculties to their normal condition, but habitual intemperance in work is sometimes as injurious as other excesses. When the brain is tired and fails to respond, it is time for recreation and diversion. There are some men who boast that they have never taken a vacation, but if the amount and quality of their work were carefully estimated, it would probably appear that it would have been better both for themselves and their employers if they had done so.

Inaccuracy is, perhaps, the greatest sin next to dishonesty, of which the engineer is capable. Its results are waste of money, danger, accident, and frequently loss of life. Failing bridges, broken dams, collapsed buildings, are likely to follow the misplacing of a decimal point or the omission of some essential in computation. But accuracy in calculation or in execution is not sufficient to avoid trouble. Accuracy in expressing conclusions, clearness in recommendations, and precision in describing the work to be done in contract and specification,

are of the utmost importance. Serious loss and an enormous amount of litigation result from looseness and lack of clearness in description of the work to be done and the relative obligations to be assumed by owner and contractor in the specifications commonly prepared by engineers and architects. Purely technical training may result in accurate thinking through the medium of formulae and in a proper regard for inexorable natural laws, but it will not give facility of expression in language which cannot be misunderstood. This is an accomplishment which can only be acquired by what are known as the culture studies and by more or less familiarity with good literature. A curriculum which is conspicuous by the absence of such culture courses, or which has not been preceded by a fairly liberal training is not likely to produce the kind of engineers we are endeavoring to describe.

Self-Reliance. This does not mean self-satisfaction or self-conceit, nor does it imply unwillingness to take advice or profit by the opinions and experiences of others. It means that after having secured the available information upon the subject under consideration, after being assured as to the soundness of theory and having tested the accuracy of calculation, one's conclusions should be defended with confidence and enthusiasm. It means, further, that when in trouble the first thing to do is not to call for help, but to get oneself out of his trouble as quickly as possible. The man who does not believe in himself and in the soundness of his theories and conclusions will find it difficult to induce others to accept them.

One of the most valuable assets in any professional or business career is tactfulness, and to no one is it of greater value than to the engineer. His theory may be all right, his plans may be excellent, his projects may be well conceived and carefully thought out, but it may be presented in such a way that it will not appeal to a superior officer, a commission, or a board of directors. Natural difficulties may be overcome by technical skill or by sheer force of energy and persistence, but prejudices and antagonisms may be aroused which will prove insurmountable. In dealing with men as with nature, it is well to follow the lines of least resistance. If incredulity be met with scorn, if irrelevant questions be ignored or answered with contempt, if objection be treated with impatience, the best matured plans are apt to come to naught. It is always possible to make concessions with respect to nonessentials which the layman is frequently unable to distinguish from essentials; in fact, it may sometimes be well to have a supply of nonessentials to trade with. When a moral principle is involved, the man who will stand or fall by it is always to be commended, and the instances are rare in which he will not win. But it often happens that we can-

not get all that we would like, and in such cases it is well to get the best we can under the circumstances. You may say that the man who will do this is an opportunist. Well, most men who attain results are opportunists. In fact, it may be said that the tactful man is courteous, considerate of others' opinions and even of their prejudices, is willing to go around rather than through an obstacle, and is an opportunist.

The qualities which we have considered may be thought enough to insure success, but to make success substantial and well worth attainment, one other is necessary, and that is integrity. Not honesty which is merely good policy, not a relative degree of rectitude which is measured by that of other professional or business men, but a devotion to the highest ideals of truth, honor, and justice.

The engineer is often, yes, usually, called upon to safeguard the interests of a client which may be an individual, a business or public service corporation, a state or a municipality, and also to act in a judicial capacity between his client and the contractor. It matters not from which of the parties to the contract he receives his compensation, his duty is to decide questions in dispute with entire fairness and equity to both. This is often a trying position, and the man who occupies it is sometimes subjected to great temptations and subtle influences which are not easily recognized. Only a keen sense of honor and a realization of his responsibility will guide a man aright under such circumstances.

The engineering profession is an exacting one; he who follows it deals with natural laws, the infraction of which means disaster; his deductions must be based upon premises which are incontrovertible and which can lead to but one conclusion; polemics and casuistry have no place in his mental equipment. His moral nature should reflect his mental habits, and in all his relations there should be no compromise between truth and falsehood,—between uprightness and moral obliquity. You may say that the professional standard implied by the qualities and habits just enumerated is very high and beyond the reach of most men. It is high but it is not beyond the reach of any man who is determined to attain it.

We have considered only those qualities which most intimately relate to one's duty to himself, his fellows, and his profession. But for the man who would most effectively serve the public and who would emphasize the dignity and importance of his profession, still more is necessary. There is a feeling all too common that the work of the engineer is strictly utilitarian, and that if his designs are structurally sound there is little need for him to concern himself with artistic appearance,

—that if his client wants beauty he can go to an architect or a specialist in landscape work. The engineer with the liberal training, the importance of which it has been my purpose to emphasize, will readily appreciate the necessity of making his work as attractive in appearance as is consistent with utility and economy. Symmetry of form, harmony of color, and consistency in detail, do not necessarily involve additional expense. The American people are coming to realize that beauty is a valuable asset. In this respect the Latin races have been far ahead of us, while the Germans, in their city planning and embellishment, have lately taken, perhaps, the first rank. A checkerboard city plan, with no emphasis laid upon important streets, and entirely lacking in eligible sites for public buildings, as is inevitable in such a plan, would not be considered in a European city, and all over this country there is now being manifested a keen desire to correct our mistakes in city planning and to add at enormous expense the dignified thoroughfares and open places which were omitted when the cities were laid out. You are doubtless familiar with the ambitious plans of San Francisco, Chicago, Cleveland, and other cities to substitute something dignified and beautiful for what is now distinctly commonplace. In one of these cities the plans are well on the way to realization. The engineer must train his own taste in such matters, and he should also be willing and anxious to collaborate with the architect and the artist in order to produce satisfactory results.

Plutarch tells us that when the Athenians protested that Pericles was squandering the public money in his efforts to beautify their city, he replied: "Since it is so, let the cost not go to your account, but to mine, and let the inscriptions upon the buildings stand in my name." At this they cried aloud, bidding him to spend on and lay out what he thought fit from the public purse and to spare no cost till all were finished. These old Greeks had an appreciation of the value of beauty to their city which we of the Anglo-Saxon race and traditions have been slow to realize. A French writer has put this in epigrammatic form when he said: "The beautiful is often more useful than the useful." This acknowledgment of the greater appreciation of artistic value shown by the Europeans, and of the more satisfactory results of their city planning must not be construed as advice that we should imitate them and try to improve our cities by destroying what we have and making them over in conformity with Old World models. My plea is that the engineers who are charged with the duty of planning our new and extending our present cities see to it that the necessity for this costly work of destruction and reconstruction is avoided.

Proper equipment for the highest usefulness in the engineering profession depends in large degree upon the use a young man makes of his opportunities during his professional course. There are a great number of excellent technical schools in this country, and the work done in some of them is doubtless more effective than that in others; but after all, the results depend chiefly upon the man himself. I want, however, to emphasize the special advantages of a small institution such as this, where the student has a better opportunity to gain that inspiration from the teacher which close personal contact is likely to promote. Elaborate equipment and large endowment are not everything; in fact, they are but a poor substitute for the small classroom unit and the resourcefulness which comes from the necessity of working things out for oneself without the aid of too much demonstration.

Permit me also to caution both teacher and student against the tendency to undergraduate specialization which has lately been shown in some of our engineering schools. There is a temptation so to mould one's course as to fit him for the greatest earning capacity immediately after graduation. Most of you will follow some special line of engineering work. What that is to be will depend largely upon circumstances, opportunity, or even environment. Students should not restrict their future usefulness by a one-sided preparation for a particular kind of work. It is true that their earning power might be somewhat greater during the first few years after graduation, but the man who is thoroughly trained in the fundamentals of engineering education will find himself far better able to avail of the opportunities which may come to him.

Thorough preparation is essential to one who would gain the maximum of benefit from his professional course. An academic degree is not within reach of most engineering students, but if by any sacrifice of time and money it can be attained, it will be of enormous value. If it is out of the question, and the student has not had the advantage of a fairly liberal preliminary training, then my advice is to avoid the institution whose course is entirely technical, with no place for culture studies. There was a time, not many years ago, when engineering was scarcely considered as a profession, when the engineer was thought to be little more than an educated mechanic. That time has passed; engineering is now recognized as the great creative profession, and its dignity and emoluments have correspondingly increased. Let us insist that it also be classed as one of the learned professions.

Members of the Graduating Class: I have endeavored to emphasize the importance and dignity of the engineering profession and

the prominent part which the engineer must play in the further development of this country. I congratulate you that you have chosen this profession for your own. You have probably received a great deal of advice, especially during the last few days. All of it has doubtless been good; much of it you will forget; some of it you will remember. I am not here to preach to you, and yet I will venture a few personal words in conclusion.

You have done faithful work in this Institution and are about to be rewarded by receiving its degree. This does not mean that you are now engineers. It means that you have received such training that by intelligent application of what you have here learned you may soon become engineers. Your education is not completed, it has only begun. Thus far it has been secured at the expense of parents or other relatives; possibly some of you have paid for most of it yourselves. See to it that it is not completed at the expense of your employers or clients. You will doubtless make some mistakes and will profit by them, but he is fortunate who is able to profit by the mistakes of others as well as his own. It will be well for you to keep in touch with your professional brethren, to identify yourselves with professional organizations, and to make yourselves familiar with current professional literature, but do not limit your acquaintance to engineers or your reading to engineering books and periodicals.

If you should enter the public service, do not think that influence will take the place of industry and honest endeavor. The day of the political engineer has passed. You will be called upon to exercise functions which are judicial in their nature; strive to be absolutely fair and just. Do not deceive others, do not let others deceive you, and do not deceive yourselves. Your profession is an intensely practical one, but there is every reason why the engineer should be an idealist, provided he is not a doctrinaire.

Be loyal to your profession, loyal to your Alma Mater, loyal to your God, and you will attain true success. Such success I wish you all.

THE ENGINEER AND THE COMMUNITY.

By

Dr. William McClellan.

Most of Dr. McClellan's address, which was delivered in 1909 at the Annual Commencement of the Thomas S. Clarkson Memorial School of Technology, is in the main similar to other commencement addresses herein given; but his conclusion deals with a subject that needs emphasizing, hence it has been reproduced.

Dr. McClellan was educated at the University of Pennsylvania, where he received the degrees of B. S. and Ph. D. For several years after graduation he did all kinds of street railway engineering for the Philadelphia Rapid Transit Company; and in 1905 he went to New York City to work with Westinghouse, Church, Kerr, and Company.

He is now located in New York, where he holds the positions of Vice President of the Campion-McClellan Company, established in 1907 to do general engineering and construction work for industrial and electrical corporations; President of the McClellan-Lines Company, established in 1910 for the manufacture of mechanical devices; and Consulting Engineer for the Public Service Commission of the Second District of the State of New York.

Editors.

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* * * * * * * It is important therefore, if we are to rise to the full dignity of our profession and exercise in the community the greatest possible influence, that we recognize our responsibilities. We must understand that we make our impression on the community not in some but in all our activities,—our walk, our clubs, our societies, our diversions, our expressed opinions, and our interviews. We must remember that while working with materials we are working for men. We must understand that while called upon to examine details carefully we must at all times discard trivialities. We must learn to cultivate that chief faculty of a really great man, his ability to distinguish the essential from the non-essential. We must learn especially to keep the tools of our profession out of sight, and sharpen them in private, or putting it differently, let us dwell more on the things we do and their effects rather than on the beauty of the technicalities involved.

We are expected to have opinions, and must be able to express them. Opinions, however, are not manufactured off hand, but are the result of thinking. If the opinions are to be broad and comprehensive, they can only be so as a result of continuous broad thinking. If they are to be expressed forcibly and intelligently, it can only be done because we have practiced this art consistently. Get rid of the idea so prevalent among engineers that talkers are not doers. This is all wrong, and history proves it, but when you do talk say something, and only after proper consideration.

All this is comprehended in the general direction. Be an ENGINEER, without adjectives, without limitations, broad, well rounded, far beyond the millwright stage. Realize the full meaning of the title and work towards it. Glory in it, and strive for the time when you can honestly bear it. Some engineers have done this and they are not complaining about recognition by the community. It knows their names, and is proud of them.

THE HUMAN SIDE OF A MINING ENGINEER'S LIFE.

By

Edmund B. Kirby, E. M.

This address was delivered to the graduating class of 1908 at the School of Mines and Metallurgy of the Missouri State University. It is reproduced in part, not merely because of its undoubted excellence, but also to give representation to the line of mining engineering.

Mr. Kirby graduated at Washington University in 1884, taking the degree of E. M. He started his practical work in Arizona and Colorado as assayer and chemist at various plants, then took a position as Superintendent of the Philadelphia Smelting and Refining Company and built their smelting plant at Pueblo, Colorado; next he was Superintendent of the Russell Process Silver Lixiviation Mill at Aspen, Colorado, after which he began a private practice as Consulting Mining Engineer and Metallurgist with headquarters in Denver. Then he occupied for two years the chair of Mining and Metallurgy in the State School of Mines at Golden, Colorado, and at the same time did consulting work in various parts of the state.

Next we find him as General Manager of the War Eagle and Centre Star Mining Companies at Rossland, British Columbia; then as Consulting Engineer in Nevada; then as Manager of the Federal Land Company at Flat River, Missouri, for the American Smelters Securities Company; and finally as Consulting Mining Engineer and Metallurgist in St. Louis, Missouri.

Mr. Kirby is a member of the Mining and Metallurgical Society of America, the American Institute of Mining Engineers, The Canadian Mining Institute, and the Colorado Scientific Society.

Editors.

THE HUMAN SIDE OF A MINING ENGINEER'S LIFE.

By

Edmund B. Kirby, E. M.

You have now reached the time when the care and sacrifices of your families are at an end, when faithful instructors have completed their labors, when the State has performed its duty. It is now in order for you to stand upon your own feet and to go your own way.

You are assembled here today to say farewell and to receive a few directions about the trail ahead. At such a moment we need no words from you to know the inquiry in every mind "Which way lies success for me?" To this question so old and yet so new, the answer must ever be the same—"No man knows." We can, however, tell you where the chances are best and the dangers least. We can give pointers on equipment and a few friendly suggestions which will aid your journey.

So, first of all I say to you, that the way is long and hard. It leads over rough mountains and through treacherous swamps, and, disappearing, leaves you to break your own trail. Therefore, travel light. Look first to your load. Study the handicap which nature and fortune have placed upon you. So far you have not been responsible for this, but henceforth you are. Give it thought and care and little by little, by that persistent effort which never fails, you may throw it off and travel free.

And next, I would call your attention not to the Technical, but to the Human field before you. I do this, because it is so often neglected by mining engineers, and because this neglect is so apt to bring delay, disappointment, or failure. The special work of an engineer is to apply the discoveries and methods of science to the practical business of the world. Often he forgets how many-sided a man must be for this end, and then, enthusiastic and absorbed in technical details, he overlooks the fundamental requirements of life.

I urge you, therefore, not to forget that the world is made up of things and of folks, and nine-tenths of your business is going to be with folks. Science is a fascinating but exacting goddess, and she brooks no rivals. She weaves a mystic spell about her devotees and normal Human motives disappear. The love of gold, the dream of power, the hunger for social position, are all forgotten. They find themselves impelled by strange, mysterious forces, unknown to the

multitude, and by themselves but dimly understood. They pursue truth for truth's sake. They discover realities through the insatiable desire to know. Enthralled by the passion for exploration and discovery, they give profound intellectual effort, they expend lives of unsparing labor for a mere existence, often without the aid of recognition or of sympathy. Such men live apart and in a higher world.

The enthusiasm kindled in the student's heart by contact with the scientific spirit can never die out. It is and must always be the inspiration of the mining engineer. But his own life work is of a different nature—it is most sternly practical. It is the production of wealth from the forces and materials of nature. It leads out of the library and the laboratory, and into the busy world of men and affairs. Year by year it calls more and more, not for the intense and narrow specialist, but for many-sided ability, for the well-balanced man. The practical business of an engineer seldom requires profound technical knowledge, but it does demand a working knowledge of men and skill in dealing with them. He can often prosper without the former, but without the latter his chances are small. The special word I bring you today, therefore, is to seek for success among Human beings, and throw off the personal defects which handicap you in the world of men and women.

This school has done what it could for your equipment. It has performed the duty for which it was created; it has awakened and developed your intellect; it has acquainted you with the methods and resources of science and of your profession. You represent the conscientious labor of earnest men who have brought you all to a certain standard of mental and technical equipment. But your social equipment, that combination of personal qualities which is to help or hinder your career, has been left to chance. Fortune has bestowed upon you the accumulated result of individual heredity, of early associations and of other environments, and in no two men is this result alike. The only common training has been that due to your own student life, together for four years. This has knocked off corners and rubbed down rough places, and is generally recognized as one of the chief objects of a college education. So, as you stand today, varying in these personal qualities, I call your attention to the fact that henceforth you are your own architects and can re-construct as you please. To youth all things are possible, and you can, if you really wish it, change these qualities in any way you like.

You will gradually learn what is wanted. The business world is not interested in the details of your education. It is generally understood that the completion of a course like yours indicates that the man

has made good in his first test, that he has carried through successfully his first serious undertaking. This gives promise for the future, and the fact of technical training assures ease in breaking a new man into the business. But you do not yet know that the questions an employer asks are merely these: Has he good sense above the average? What are his personal bearing and address?

You will find that a diploma is of little interest to others, but a likeable personality is a passport, good for life and in all countries. In time you are to discover that tact and diplomacy solve more problems than engineering formulas; that a memory for names and faces will help you more than one for minerals and rocks. Sooner or later you will know that good sense, that ability to decide which of any two things is the more important, is an asset beyond price. You will awake to the fact that valuable as is skill in the higher mathematics, it will never push you to the front like the ability to write a letter which will really do its work. How will you deal with people if not through language, that means by which your thought and will may reach the consciousness of others, that delicate and subtle medium necessary for the most simple affairs of daily life, yet capable under a Master's touch of swaying a multitude, of moving the world? How far have you learned its use? You have studied the reactions of chemistry, but how much have you learned of those subtle human reactions which break down indifference and create friendship?

If your training as engineers has been effective, it has bred in you the impulse to search out facts, however unpleasant they may be, and to look them squarely in the face. In sorting over your equipment, you who do not find yourselves compendiums of all the virtues will not be lonesome. You have, moreover, the consolation of knowing that anything lacking is yours for the effort, if you want it hard enough.

But you say this wanders from engineering matters. These are the winning qualities for all men. I answer "Quite so, the sucessful mining engineer is the successful man." * * * * *

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And now a few suggestions about your life work.

There are men who shut themselves up, and out of their inner consciousness evolve some great work, such as an invention, or a book. Occasionally also, men go into the wilderness and discover a mine. But such individual play is rare and its chances are small. The real business of the world is done by team-work, and you must qualify for this. It is done by innumerable bodies of men, each of which is under some kind of organization, intended to combine its units into an efficient human machine, capable of the business on hand. Now, every such

machine, whether it be a baseball nine, a section gang, the force of a great steel-plant, a railway system, or an army, works more or less badly. The individuals who compose it, from the general to the private, from the business head to the lowest employee, have human weaknesses which are much alike, and the results are friction, loose joints, lost motion, and sand in the gears. Nevertheless, the outfit goes creaking along, and usually gets there, often to its own surprise.

There are weak points in abundance, not only on the Human, but on the Technical side of every business. There is a best way to do each operation, from the handling of a shovel, up, and it is not always done in the best way. Moreover, methods, processes, and machines are constantly changing, constantly advancing. These two conditions, the imperfection of technical methods, and the faults of Human organization, will provide your openings. It is because of them that the world is so full of opportunities for men who have the combinations of sound technical training and good sense.

When, therefore, you hold a job, do not waste time in complaints and fault finding. You will continually see waste and loss, things which are wrong, things which need improvement. Others see them too. If you have sense you will notice everything, but will keep your mouth shut. Some day your chance will come. Your advice will be asked. Some day you will be given charge of a small piece of work, of a few men, and may then bring out your ideas by doing this work better and more cheaply than the man before you.

An able man will move up from any job and there are no rules for fortune. But in your profession the chances are generally somewhat better for those who are able to start as workmen, or in positions close to the working force. If the machine of which you are a part is too bad, get out, but while you are in any business organization, be loyal to it, hold up the hands of those above you, and keep your own work as free as possible from the faults you notice elsewhere.

Your duty now is to get busy. Get into action somewhere, if you cannot at once find work in the line desired, take anything temporarily. Concentrate yourself upon your job until sure that you are holding it down, and then turn your attention to other men and other work. Beyond this you will play the game as fortune and your own will dictate.

Play it straight. This may sound easy to you, fresh from the wholesome influences of your homes and the fair-play of boy democracy, but in years to come, when the passions of the fierce struggle take hold of you, when copy book maxims fail, when you see men around you winning safety, fortune, and power by unscrupulous methods, unless

you have higher motives for honesty than the belief that it generally pays, you are quite likely to resign from the Straight Men's Association. It is gratifying to be able to tell you that you will find your profession much above the average in its percentage of clean men.

It may sometime be of service to know that to be fired from a job is often the best thing that can happen to a man, if he is really built of the right stuff. It galvanizes him into life, jerks him out of a rut, tests his own resources, and makes him start fresh in new surroundings and with new people.

Throughout your career you will make errors and have occasional bad falls. Avoid the delusion that such occurrences are fatal. No error is serious, unless you fail to learn its lesson, or allow it to weaken your courage. Some of the most successful men I have known had failed so many times that they stopped remembering. Because they stopped, they succeeded. If by the caprice of fortune, any of you should eventually meet with disappointment, if you should fail to realize your hopes and ambitions, you will, by that time, have learned that your only failure has been to escape the common lot of man. You will, by that time, understand the Arizona epitaph, "Life ain't in holding a good hand, but in playing a poor one well."

Under normal conditions your status will long be simply that of the Human animal, struggling for the existence of self and family, differing from other animals only in the complexity of itself, its environment, and its struggle. This struggle for existence is your first duty, and may long demand your whole attention. But for those of you who respond to the spirit of the age, the time should come, by middle life if at all, when your eyes will be lifted from the details of self seeking. You will suddenly become conscious of the great Human organism of which you are a part and of your relations to it. You will have attained intelligence. Thenceforth a part of the awakening soul of humanity, you will see through the surface and into the injustice and unhappiness of the world around you. When this awakening comes, with the new duties it imposes upon your conscience, follow them. Choose what line of action you please, but do something. You may elect either to pick up wounded, or to get into the fighting line somewhere, but get busy. Join those who are trying to make the world a decent place to live in.

Your destinies will be determined by the mingled influences of ability, hard work, and pure luck. Capricious fortune will deal kindly with some of you and roughly with others. Some of you will reach wealth and power, others will not. As your head swells with success, do not forget how much of it is due to chance. Do not forget a struggling classmate. In a few months the petty differences and

jealousies of your college life will have passed into oblivion, but the man who has rubbed shoulders with you through that experience has a grip and pass-word that you cannot forget. Throughout the world, among the yellow, the brown, the black, and the white, it is the law that the call of a comrade must be heard.

And now, gentlemen of the Class of 1908, in behalf of the Profession of Mining Engineers, I welcome you to its ranks. No profession is more important, none has a brighter future. It is your special work to bring forth the hidden treasures of the earth, and to convert them to the use of man. Yours is the mother of industries. Where mines are opened, there the wilderness blossoms into towns, railways, agriculture, manufactures, homes, and all the varied forms of civilized life. Yours is the creative work of pioneers, and your field is the world. Within a few years you will be scattered from the east to the west, from the tropics to the frozen regions of the north. Your duties lead you to the forest, to the mountains, and upon the desert. You are to labor in the roar of machinery, in the smoke of furnace-fires, and in the cities of candle-light. In time you are to become leaders of industry in distant places, to be entrusted with power over men under many skies. Wherever this may be, whether in the centers of our American civilization, or among strange peoples and amid strange tongues, the State of Missouri expects you to bring honor to her name. Our profession looks to you to uphold and to advance its standards.

SUCCESS.

By

Dr. M. E. Cooley.

Mortimer E. Cooley was born in Canandaigua, New York, March 28, 1855, and lived on a farm till his nineteenth year. His early education was secured in a district school and later at the Canandaigua Academy, noted in those days for the thoroughness of its work. For two years he taught in a district school, the money thus earned serving to pay his tuition at the Academy. He used to walk daily to and from the Academy, distant from his residence three and a half miles, studying *en route,* as no time was available at home.

In the summer of 1874 he went to Annapolis on his own initiative, without assistance or influence of any kind, and took the entrance examination for the U. S. Military Academy, coming out number seven among seventy or more applicants. At the Academy he captained the class crew for two years, rowing in one regatta. He also excelled in fencing and broad-swords, of which he was very fond. He graduated seventh in his class in June, 1878.

He served first on the U. S. S. Quinnebaug on the Mediterranean, and was afterwards transferred to the U. S. S. Alliance of the Atlantic Squadron. In March, 1881, he was ordered to duty in the Bureau of Steam Engineering at Washington, and in August of the same year he was sent on detached duty by the Navy Department to Ann Arbor for a three years' detail to teach mechanical engineering at the University of Michigan. By special request of the Board of Regents, this detail was extended another year; at the expiration of which time, by the pressing invitation of the President and the Board of Regents of the University, he resigned from the Navy and accepted the chair of Mechanical Engineering, which he has continued to occupy to the present time. Since 1905 he has been Dean of the Engineering Department. To Dr. Cooley's good work are greatly due the rapid enlargement of the University and the success of its engineering graduates.

In addition to his scholastic duties, Dr. Cooley finds time for professional work; and he is often called upon to act as consulting engineer on projects and constructions in his specialty. Again, he has taken time to devote to municipal politics, having been President of the City Common Council of Ann Arbor for two terms.

Dr. Cooley is a member of numerous engineering and scientific societies, and has held office in some of them.

His busy days have left him little time for literary work other than college lectures, although he is frequently called upon for addresses.

He is a member of the Michigan State Naval Brigade; and he served as Chief Engineer on board the U. S. S. Yosemite during the Spanish-American war and later at the League Island Navy Yard. He received as a token of appreciation of his naval services a silver medal from the City of Ann Arbor, a bronze medal from Detroit, and a bronze medal from the State of Michigan. He also received from the U. S. Government both the Service Medal and the Sampson Medal.

He received from the University of Michigan the honorary degree of Mechanical Engineer in 1885, from the Michigan Agricultural College the degree of Doctor of Laws in 1907, and from the University of Nebraska the degree of Doctor of Engineering in 1911.

In view of such a record, Dr. Cooley is certainly well qualified to write upon the subject of "Success," and his dicta thereon ought to carry conviction. His thrilling words in this address should arouse the enthusiasm of every young man who reads them and develop in him worthy aspirations of the highest order.

Editors.

SUCCESS.

By

Dr. M. E. Cooley.

It has occurred to me that I could do no better in this my final word to you than to try to answer a question which each and every one of you has asked himself, or should ask himself; viz. How best can I succeed in my chosen field of work? What should I do to make of myself the greatest success? It is not an easy question to answer, for, like many an algebraic problem, the unknown quantities are greater in number than the equations embracing them. Moreover, it is difficult for a young man to see himself as others see him. It would be fortunate indeed if the young man could write down on paper the several equations of himself so that he could study them deliberately and then apply the principles of mathematics to their solution. The problem would be found to embrace such elements as inertia, velocity, acceleration, momentum, vis viva, and maxima and minima. Indeed a knowledge of your limitations is of the first importance. The whole problem may be stated in two words: *Know thyself.*

The first and most important question to ask one's self is what did God intend I should do in the world's work? Many, if not most failures can be charged up to not having learned the answer to that question. If on a close analysis of yourself the answer points to something different from what you had planned to do, do not hesitate to change, and to change at once. For be assured that if you do the work you were intended for you will make a success of it, and nothing can prevent it.

It will require courage in many instances to accept the result of such an analysis of one's self, but remember the physics of the problem, and that as naturally as water runs down hill, and requires power to force it up hill, so with you in your work—if selected with regard to your fitness, success will flow readily, and if not, power will be continually required to bring about success.

A young man was graduated from this University in engineering in 1905. He came here off a farm and helped himself through college by work. He applied himself faithfully to his chosen profession for nearly five years, and was fairly successful. He paid back the money he had borrowed while in college, helped bear some of the ex-

penses at his old home, and saved the rest of his money. He has now gone back to the farm in the belief that for a man of his temperament a greater measure of success could there be obtained than in engineering. I know that young man intimately and am sure he has made no mistake. He probably would never have been more than just a good average engineer, but he will make a success as a farmer. His education has not been wasted. It will be a great comfort to him in the years to come; and even if it has done no more for him than to enable him to settle the one great question, it was amply justified.

It is important to know just what constitutes success. Do not make the very common mistake of measuring success by the amount of money you can earn. One must have money and enough to live on, but it is not the all important thing at the beginning of life. It becomes really important only when one's working days are drawing to a close, and enough must be had to bridge over the shoals to the deep water where the ferryman waits for the final passage.

In one sense success is the realization of one's ambition. It is the achievement of the result of one's plans and labor. It is the bringing about of the end sought to be accomplished. We are sometimes confused, I think, by the surgeon who says the operation was successful notwithstanding that the patient died. In the arts we may have its parallel in the case of a machine which produces the result intended, but fails because there is not enough demand for the product, or because of insufficient raw material to work upon.

Professor John E. Sweet, the father of the Straight-line Engine, used to tell the story of the man who designed and built a most perfect machine for manufacturing pins. It was a wide step in advance of the art. A large factory was built in Syracuse, and when completed the proprietors went into the market for pin wire. The price quoted was so high as to lead to the remark that at such a price the wire cost as much as the finished pins. "Oh," said the wire merchants, "if you would like to have the wire run through the pin machines and made into pins, it can be done at the same price." There was a case of a success which, owing to other circumstances, resulted in failure.

Failure itself is often success. Such a case is found in the problem which one has attempted to solve expecting a certain result, and in the solution of which it was completely demonstrated that no such result is possible. It may be quite as much of a success to prove that a thing can not be done at all, and it may be more of a success, than to achieve a partial result which leads on to the expenditure of more time and money with the final result a failure after all.

In measuring success in life I would like to start with citizenship. Let everyone, first of all, be a good citizen, one who commands the respect of his neighbors; one who has ideals and is successful in inspiring them in others, so that the community and the home are all better for those ideals. A man who conducts himself so as to maintain his self-respect is a great success. A man who lives his life within his income and meets his obligations is a success. The man who by his example creates in his neighbor a desire to emulate him is a success. A man who never shirks responsibility, and takes upon himself duties to be performed and does his best in performing them is a success. In none of these things need money be considered, except sufficient to live on and do the things which come to hand.

I do not mean in my definition of success to omit the truly great things, but everyone knows of them, and they need not be mentioned. I want you, young men, to go out into the world prepared to credit yourselves with being successful, even if you do not acomplish something which the world would call truly great.

One of my old friends wrote me the other day a most interesting letter concerning himself. After graduating from the Arts Department here at Michigan, he attended an eastern engineering school. He had often wondered why he did not get along better in the world. The lesson is so valuable and so pertinent to the spirit of my remarks this morning that I have taken the liberty of quoting parts of his letter. Understand it is from a man now nearly or quite fifty years old. This is his letter:

"It has just entered my head that many engineering graduates might be the better for a little bit of advice, or perhaps, warning, in regard to the necessity of discriminating between knowing how work should be done, and knowing *how to get it done.* I have suffered all my life from knowing how things should be done, and leaving them for some other fellow to finish; and it is only within the last year that I have had my eyes fully opened to the folly of such a plan of action. The extra work of completing the job is nothing to the man who has done the preliminary work and laid out the completion of it. But the man who actually gets it done and sees that it is finished, who has to go over the other man's preliminary work and become familiar with the plan for its completion, before he starts, is the one who gets *all* the credit, and moreover *he has a right to it.* He is the man who gets the *money* anyhow.

"I never discovered this little secret until I struck the sales end of the engineering business, and found that unless I carried my work clear through to where I could say, 'Here! Make this, as shown and

specified. Deliver here on such a date, for such a price, to be paid on such a date,' the work was not complete and I could claim no credit for it, unless, of course, conditions were such that it was a physical impossibility for me to get all the data myself and attend to the wind-up before it was turned over to the production end.

"The man who took the trouble to teach me this, is fifteen years younger than myself and never saw the inside of a technical school. He got his engineering in the shop, and at sea, and was absorbing business principles all the time. Eight years ago he was working under me at the 'Brown-Hoist' in Cleveland, and when I went to work for him a year ago, I found he had been analyzing my character while working for me, and had his whole plan prepared for reconstructing the inside of my head, and *he has done it.* I have for some time been puzzled to know just what it was that I had learned that made me succeed as I had never done before, and have concluded that it is simply this: Carry whatever you do to a conclusion, to a point where you can turn over something concrete, so that all that remains is simply an order or a set of directions, the origin of which need not be investigated, and in which there is nothing to be checked. In other words, to do the work so that you can tell the next man just what he is to do, and so that he can hold you responsible for what has been done up to the time he receives the order.

"I suppose to many, even very young engineers, these are self-evident truths, and to them it might seem childish to put such things into words, but from my own unpleasant experience, I suspect that the majority of young men are not alive to the matter, and that many do not get wise till quite late in life, like myself, and some (a good many) never learn it."

There is one rule I have always tried to follow. It may not add much to one's success as measured by money, but it has at least afforded a great amount of personal satisfaction. Often when an engineer is called upon in a consulting capacity, he is asked to produce a particular result, and not infrequently is told that no other result is needed or desired. This I have as a rule declined to do, and when urged to hurry my report have said, "I can not give you my report until it is finished. While you may be satisfied with the work already done, I am not. When I am satisfied you also will be satisfied." Work should always be carried on to a point which will enable the engineer to advise in light of all the things developed during the investigation. That is particularly true of a new project. If reported on after only a partial investigation, work might have been commenced and money expended along lines found, after a complete investigation, to be entirely wrong.

It is an engineer's duty to work out problems for his employer which will show conclusively all that can be known for and against a project. Moreover it is a duty one owes himself, for one's reputation should not be jeopardized. A reputation is an engineer's capital. Properly treated it will bear a good return, but ill treatment will not only diminish the return but ultimately destroy the principal. Young men, you must cherish your reputation above all things, if you are to continue in the practice of engineering.

A young engineer once handed me a letter in which he was offered a contract in a certain way, and asked "What would you do about it?" I replied, "Young man, if you expect to continue in engineering work, only one course is possible; if you plan to go into other work two courses are possible." He smiled—and is still engaged in engineering work and very successfully. Once an engineer has been purchased, it speedily becomes known among salesmen, and sooner or later among the engineer's employers, and that is the beginning of the end, if not the end itself.

And now a final word. Be true to your employer. You may not agree with him or with his policies. You may dislike him, but as long as you work for him and receive his pay, be true to him. Such conduct will win for you your employer's respect, and he will aid you when you go from his service. Always give your employer ample notice of your intention to leave, and give him the true reasons if he asks them. Make a sacrifice, if necessary to prevent any embarrassment which might result from your leaving. These are little things, but they win.

Be content with moderate or even small pay, if there is a future in sight. Oftentimes the small beginning makes the most satisfactory ending. It is better to start at $45 or $50 a month and advance steadily upward with no limit in sight than to start at $75 or $80 with a known limit of advancement ahead of you. Put by a part of your earnings, 10% at least. Put it in a separate bank and do not touch it until you have to. If your pay is $50, put by five of it and if $100, put by ten. When the accumulation makes $500, take it out of the savings bank and buy a good bond. In a short time you will have two or three bonds. Then when you want to raise money, to go into business it may be, you can offer your bonds as collateral and get the money without asking anyone to go on your note with you. It gives a fine feeling of independence and enhances one's manhood.

Probably no better example of the qualities which make for success can be found anywhere than in that little story entitled "Carrying a Message to Garcia." When asked if you can do a certain thing, let your answer be "Aye, Aye, Sir," then go about it and do it. If in the

attempt you find yourself in a hole, climb out. If you can't climb out, then die in the attempt. Don't be a coward, be courageous and brave and always in a manly way. Let me give you, in closing, the lines of John Trotwood Moore entitled

SUCCESS

'Tis the coward who quits to misfortune,
'Tis the knave who changes each day,
'Tis the fool who wins half the battle,
Then throws all his chances away.

There is little in life but labor,
And tomorrow may find that a dream;
Success is the bride of Endeavor,
And luck—but a meteor's gleam.

The time to succeed is when others,
Discouraged, show traces of tire;
The battle is fought in the homestretch—
And won—'twixt the flag and the wire.

SOME OF THE ESSENTIALS OF SUCCESS.

By

Dr. Chas. Sumner Howe.

To supplement Dr. Cooley's inspiring words, some extracts from Dr. Howe's address on a like subject to the 1910 graduating class of the School of Mines and Metallurgy of the Missouri State University are here reproduced. Dr. Howe is President of the Case School of Applied Science, the recipient of numerous academic degrees of the highest order, and an engineer of acknowledged ability and experience. Want of space prevents the reproduction of the entire address, which certainly is interesting and valuable from start to finish.

Charles Summer Howe was born in Nashua, N. H., September 29, 1858. When he was a few months old his parents removed to Boston, where they lived for many years. He received his grammar school education in Boston and his high school education in the town of Franklin, Massachusetts. He entered the Massachusetts Agricultural College in 1874 and was graduated therefrom in 1878; then he passed a year in post-graduate study at Amherst, taking up the subjects of mathematics and physics; and finally, he spent a year in graduate study at Johns Hopkins University, taking up the same subjects. He has received the degree of B. S. from the Massachusetts Agricultural College and Boston University, that of Ph. D. from Worcester, that of D. Sc. (Hon.) from Armour Institute of Technology, and that of LL. D. (Hon.) from Mt. Union College and Oberlin College.

His career as an educator has been constantly onward and upward, starting as Principal of a preparatory academy in Colorado, then acting as Professor of Mathematics and Astronomy at Buchtel College, Akron, Ohio, then taking a similar position in the Case School of Applied Science, at Cleveland, Ohio, and finally serving as President of the latter institution.

He belongs to many of the leading technical and scientific societies of America, and has held high offices and important appointments in a number of them.

In civic life he is equally distinguished, having held influential positions in Cleveland; and he has served on several important National Commissions.

Editors.

SOME OF THE ESSENTIALS OF SUCCESS.

By

Dr. Chas. Sumner Howe.

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A few weeks ago I listened to an address upon the subject "Engineers as Leaders." The speaker proceeded to compare the number of prominent engineers with the number of men prominent in other professions, and then drew certain comparisons from his figures. I have never felt very much interest in the question of preparation in a technical school for leadership, either among engineers or in the world at large. Only a few can be leaders, the large majority must hold subordinate positions. If the technical school made a special business of trying to educate the leaders, it would not properly educate the great bulk of its students, for they will be obliged to carry on the everyday, ordinary work which falls to most engineers. But there is one point in regard to education which does interest me exceedingly; that is, education for success. Now, success is a very much abused term. It has a certain definition in the dictionary, but its meaning to an individual generally depends upon his views of life. One man considers that success does not come to him unless he acquires great wealth; another, to be successful in his own estimation, must receive honors from his fellow citizens; another must reach the top of his profession, and so on. It is evident that if these are the views of all men in regard to success, few of them will attain their goal—for comparatively few can be very wealthy, but few can hold distinguished rank, but few can be at the top of their professions.

My definition of success is this: A man is successful when he continually does all that it is possible for him to do. All men are not alike. One man may have greater intellectual power than others; another may have greater bodily strength; another may have a faculty of keen insight; another may have the peculiar quality of getting along well with other men. Now, the man of medium ability cannot hope, as a rule, to reach the same high goal that can be attained by the man of great intellectual endowments; but I claim that if the former accomplishes all that his powers will enable him to accomplish, he has been just as successful as the latter, although he may not have done as much of the world's work.

Whether you agree with me or not in my definition of success, you will at least allow that every man should try to accomplish as much as possible—that he should at all times do his very best.

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I believe it is generally true, that if a man is ready for promotion, sooner or later it will come to him. Most of you undoubtedly have heard men say, "No, I am not going to work any harder; I am doing now all I am paid to do." The man who achieves success and secures advancement always does more than he is paid to do; that is the kind of man any firm wants. No employer will hire a man unless he can make money out of him, and the more money he can make, the better pleased the employer is with the man and the more desirous he is to advance him. This is one of the paths to success—do more than you are paid to do, and—do it cheerfully.

The young engineer must know more than his own work or the work of the man just ahead of him. He should study the work of his company or his firm, and find out its relation to that of other companies and firms. He should know where the firm's raw material comes from, approximately what it costs, all the steps in its treatment, what the final product is, where it is sold, what it is used for; in fact, he should endeavor to gain a comprehensive idea of the whole business.

The successful engineering graduate will subscribe for the leading technical magazines in his line of work, and he will not only subscribe for them—he will read them, in order that he may keep posted in regard to what men in his profession are doing, not only from the engineering standpoint, but from the manufacturing standpoint as well. Too many technical graduates never take a technical journal. They say they do not need it for the work they are doing, which is probably true, and if they continue in that frame of mind, the probability is, they will never need to take the journals, because they will not rise to positions of high enough responsibility to make it necessary. The successful man—the man who is doing all that is in him to do—must know what other men are doing, and he must put this knowledge to use in the work which he does from day to day.

I believe every engineering graduate should keep a card catalog of articles and books which he reads, and these cards should give the information under so many different heads that it surely can be found when needed. Almost every man has at some time in his career wanted very much some article which he remembers having read but cannot place. Usually, this occurs to men every week or every day. Knowledge is valuable only as it can be used. No one can remember everything which he has read; no one can know all there is to be known;

but every engineering graduate should know where to go to find the information necessary in the successful pursuit of his profession. This means knowing how to search encyclopedias, magazines, books, etc., and I think the practice of keeping a card catalog of the important things read will pay for itself many times over. Do not be afraid of a little extra work of this kind.

The man who is looking for the highest success should study men who have been successful, to find out the secret of their success. Successful men have many qualities. I believe it will always be found that they are educated. Now, this does not mean that they have had a college education, but it means that they have educated themselves for the things they have had to do and the lives they have had to lead; and this is the kind of an education that every man must have if he is to rise above his fellow-men, no matter whether he has previously received a college education or not. A technical education does not necessarily mean success; there are many other essentials. Very frequently parents think that if a boy goes through college he ought to become a successful man, and they sometimes intimate as much to college faculties. But the fact is, if a college is to make a successful engineer out of a student, the boy must have some brains to start with. Mental ability, correct habits of thought and work, intelligence, power of application, the ability to get along with men, love of work, high character, are all necessary for success, and I am not sure that a technical education is more essential than any one of these. These qualities should be cultivated by the one who would win success, because they are necessary, if the highest goal is to be reached. All men do not have these qualities to the same degree, and a man is not to be held accountable for natural qualities which he does not possess. He is, however, to be held accountable for the way in which he uses and improves the natural endowments which are his. It is this use and improvement of that which nature has given him which I have termed "Success." It is possible for every man to develop his powers to the highest degree, and that is all that any one can expect him to do.

Again, if a man is to be successful in this world, he must have the ability to do things. The American nation demands results, and much will be forgiven him who secures them. A strenuous president may make enemies by some of the things he does, but the nation at large will overlook many mistakes if he is one to whom accomplishment has become a habit. The engineer must do things, because if he does not he is not an engineer. It is the business of men of this profession to take the materials and forces of nature and to use them for the benefit of mankind. The materials may lie in inaccessible places; they may not

be in the form or shape necessary for use. But the engineer must overcome these difficulties and transport the material to the place where it can be used and change its form or substance so that it will be serviceable to man. He may run up against some pretty stiff natural laws, and these laws will not change nor step out of the way because the man who wishes to use them is a graduate of a technical school. He must use the laws in the way in which they were intended to be used, and he must make one force counteract another until the desired result is reached. In fact, he is constantly doing things, and this is what makes him such an effective unit in the society of the present age.

I have spoken of some of the individual characteristics which make for success, but the progress of the nation is of much more importance than the well-being of an individual. A man's work cannot be called successful, no matter what it brings to him, if it is detrimental to the nation at large.

ADDRESS TO THE GRADUATING CLASS OF THE ROSE POLYTECHNIC INSTITUTE.

By

Dr. J. A. L. Waddell.

This address was delivered in 1902, nine years after the preceding one, to the students of Kansas University; and therefore it represents the conclusions of the author's more mature judgment. Mr. Harrington in compiling Dr. Waddell's "Principal Professional Papers," takes issue thus with him on one of the matters treated.

"Serious exception may be taken, however, to the strictures against municipal service. The work for which cities employ engineers is of the highest importance and requires something of the skill and tact of the politician, as well as engineering knowledge. It is true that 'practical politics' is commonly odious to the scientific man who is intent upon rendering the best possible service, but it is rare indeed that the engineer is free to act according to his best judgment, no matter what his position. If he be in the employ of a manufacturer or a contractor, competition forces him to adopt many methods which fall short of the best. Even the consulting engineer is often vexed by restrictions which his clients force upon him. In no case is one absolutely free to act according to his judgment except, possibly, in some private matters.

"But there is great public work to be done, and honest capable men must be employed to do it. The civil engineer who enters the employ of a public corporation will encounter many annoying obstacles. Politicians will endeavor to force incompetent assistants upon him; with good intent and bad, his work will be unfairly criticised; due honor and credit will be denied him; he may even be persecuted for taking his stand against corruption; but in spite of these unpleasant features of his position, he is in duty bound to conduct his office for the benefit of his employer, the public. The more difficult the position, the more credit is due if it be honorably filled. The harder the battle, the stronger the victor will be."

The placing of the office of city engineer under civil service rules, which is fast coming into vogue, removes most of the objections which Dr. Waddell used to hold against municipal engineering.

Editors.

ADDRESS TO THE MEMBERS OF THE GRADUATING CLASS IN THE ENGINEERING DEPARTMENT OF THE ROSE POLYTECHNIC INSTITUTE.

By

Dr. J. A. L. Waddell.

Gentlemen:—When your worthy President did me the honor of inviting me to address you on this auspicious occasion, I was sorely tempted to decline, because of the vast amount of professional work with which my associates and I are at present struggling. This is by far the busiest period of my entire career, and possibly you know that my life has not been an idle one. Notwithstanding this state of affairs, I concluded to accept your President's invitation, because I recognize that it is an important part of an old engineer's duty to aid young engineers in making their start in life.

I feel that I must begin with an apology for reading to you a type-written address, assuring you that, as an extempore speaker, I am an utter failure, unless it be when lecturing on technical subjects; and I think that you will agree with me that a fair written address is preferable to a poor extempore one.

Your President has left me the choice of a subject, merely suggesting that I give the boys some good advice and try to make my remarks of general interest so as to reach others than the engineering graduates. With the first portion of this suggestion I most readily comply; but I must beg to be excused from the second, as I am no hand at making popular speeches. My remarks then, young gentlemen, will be directed to you solely, hence those of my hearers who do not belong to the graduating class are destined, probably, to have a stupid time; but I can promise them that it will be comparatively short.

An engineer's success in life depends greatly upon two things: First, the thoroughness with which he has pursued his studies at his technical school; and, second, the start that he makes immediately after leaving there.

In respect to the first matter, I assume that the conditions here, like those that have always existed at that other and older R. P. I. (of which, by the way, I have the honor to be an alumnus) are such that no student who has failed to attend strictly to business during his four years' course is able to be present today in the graduating class, and

that, consequently, you all are in good shape as far as the first requisite is concerned. It is of the second, therefore, that I shall now proceed to treat, by giving you some wholesome advice, based not only upon my own professional experience, but also upon that of other engineers of my acquaintance, and having due regard to both successful and unsuccessful careers.

Generally speaking, advice to young men is a wasted effort, for it goes into one ear and comes out of the other (concerning this I can speak authoratively, for I am trying to rear two boys of my own); but in your case I hope for better things than ordinarily, as this is a momentous period in the life of each of you. Let me assure you, young gentlemen, that there is nothing which will be so conducive to your professional success as good advice from older engineers, whether they be successful men or not. In the case of the former, they can tell you what they did in order to reach the desired goal; and in the case of the latter, you can learn what they failed to do and what mistakes they made. Hence let me begin my suggestions by counseling each of you to become intimately acquainted with one or more successful engineers, and, craving their advice and opinion from time to time, follow both.

Young men just leaving their *alma mater* naturally feel that the whole world is before them, and that their success is almost an assured fact; but I tell you that you are very liable to find it otherwise, that you will undoubtedly experience many hard knocks, that at times you will feel very dubious as to what is best to do, and that you will often long for counsel from some friendly member of the profession whose opinion you can trust.

It is on this account that I advise you to become acquainted with your brother engineers as far as lies in your power and to impress upon each of them favorably your individuality, that later on you may not be forgotten. Time spent in visiting older members of the profession is by no means wasted; therefore take it whenever you can do so without neglecting your duties; and endeavor to confine your conversation with such men mainly to technical subjects, preferably those in which they are specially interested. A young engineer can often aid an older one materially by assisting him in some of his calculations and in the preparation of papers for technical societies. What would often be drudgery to the older engineer would prove to be valuable experience to the younger, consequently never hesitate to undertake, in such case, tedious computations which will lead eventually to valuable deductions, even though your reward be apparently *nil*. An engineer of the right kind (and I am happy to be able to assure you that

most of them can be so classed) is only too glad to give full credit to a younger man who has helped him in his investigations.

Concerning the benefit to be derived from an older engineer's opinion and the need for it, I can speak from experience; for many a time have I received kindly help and encouragement from my good friend, Professor Burr; yet in the old days when we were associated together at Rensselaer, being of nearly the same age, we often got beyond our depth and would have given much for some sound advice from engineers of high standing; but unfortunately it was not at our command. I can look back upon many a wasted hour in my early days, when, active, energetic, and ambitious, I desired most earnestly to devote my attention to investigations the results of which would prove useful to our profession and would tend to establish my reputation as an engineer and a technical writer. But alas! there was no one to direct my energies into a proper channel or to show me how to employ my time.

Enforced idleness for an engineer is the greatest curse in existence; and there ought to be no excuse for a member of our profession having a single, necessarily-idle hour; because he should always have laid out for the future more things professional to investigate and accomplish than he can possibly perform. It is a serious thing for an energetic young fellow (and all engineers of any account, both young and old, are energetic) to run short of work for any length of time. I well remember a period of eight months of enforced idleness that I experienced a few years after graduating, during which time I nearly wore myself out with worry and restlessness, not having had sufficient practical experience to enable me to write more than a paper or two. It is true that I had saved up quite a little money, enough to tide me over the bad times without having to appeal to my father for assistance, and that during that period I obtained a pretty sound knowledge of the French language; nevertheless I succeeded in worrying myself absolutely ill. I assure you that I would not go through those eight months again for untold wealth. They are the only part of my life that I look back upon as truly unhappy.

You young men are, in a way, much more fortunate than I was, in that I started my professional career during the depressed years of '75, '76, and '77, while you are entering upon yours at the most prosperous time ever known in the history of America. Never before were engineers in such demand, never before was the compensation for professional services so good, never before was the country so wealthy, and never before were the prospects for the future so bright. Our great republic (and believe me, although alien born, I can truly

appreciate its greatness) has entered the world's arena with the intention of taking quickly the first place among nations; and in the peaceful strife that is to ensue, American engineers of all lines will be found in the van, bearing the brunt of the struggle and, even in the most remote corners of the earth, forcing foreign nations to adopt our methods and to purchase the manufactured products of our country.

Ours is truly the greatest of all of the professions! With it none other can compare! It, and it alone, is essentially the profession of progress! To whom is due the unparalleled world-advancement of the last half century? Who are the men who have developed the resources of the North American continent? To whom are we indebted for all the great luxuries of modern life? To these questions there can be but one answer:—the civil engineers, using the term in its true and broad sense, so as to include all engineers except the military.

Compared with all other professions, ours is by far the most desirable. Lawyers, of necessity, lose one-half of their cases; therefore about fifty per cent. of their total work is failure; while all engineering work is, or should be, successful. Half of the time lawyers are retained to disguise the truth or so to distort it as to win cases for their clients, while the engineer is essentially *a searcher after truth.*

The doctor too often gropes blindly in the dark, using tentative methods and relying upon nature to help him out of his difficulties; for medicine is anything but an exact science; while engineering comes nearer being such than does any other profession.

The military man's main object in life is to destroy, while the engineer's is to construct.

The minister deals with things based on faith, while the engineer in all his works is governed by the laws of nature, which, as a rule, he understands fairly well, and with which he must comply in order to be successful.

Civil engineering is the youngest of all the learned professions; and until quite lately many people, including even some of its prominent members, maintained that it was not a profession at all, but simply a trade. However, all that is a thing of the past, and engineers are now not only considered to be professional men, but are looked up to by the populace. "Straws show which way the wind blows," hence, to learn the world's opinion of engineering and the civil engineer, we can consult the light literature of the past and present. It is not many years ago that the English novelists sneered at the engineer, terming him a "greasy mechanic" and placing him outside the pale of polite society. At that time American novelists either simply ignored the engineer by leaving him out of their *dramatis personae,* or, when he did come in-

cidentally into the plot, considered him about on a par with a boss carpenter. To-day all this is changed. Many of the prominent modern novels have civil engineers for their heroes; and in all of them the members of the engineering profession are invariably treated with the greatest consideration. In France and in French literature the civil engineer has always been recognized with due esteem, as is witnessed by the works of Jules Verne and other French writers. There is perhaps good reason for this, because the civil engineer in France for the last hundred years has always been a polished, highly educated gentleman, and generally a graduate of a school of world-wide reputation.

In our country any man or boy who can use a surveying instrument or even drag a chain or handle a rod, has the privilege of dubbing himself a civil engineer, thus lowering the profession in the minds of the public, which generally fails to distinguish between a graduate engineer and one who has risen from the ranks. Nevertheless, nowadays in this country in order to attain anything beyond mediocre success in engineering, a young man must be a graduate of a technical school, and the higher the reputation of the school the better are his chances. It is true that we have in the profession many prominent men who never had a technical school training, but they are almost invariably of advanced years.

In England there have been until lately no special schools for engineers, hence the young engineer there has had to obtain his education by the crude and faulty system of apprenticeship. On this account there may have been some reason for the low standing of engineers in the opinion of writers and society people; nevertheless, the English engineer of today ranks in his own country second to no other professional man. Again, the Institution of Civil Engineers of Great Britain is certainly the greatest and most influential engineering society in the world; and some of America's most eminent engineers are proud to be able to write M. I. C. E. after their names.

Yes—there is in my mind no doubt about it—ours is the most satisfactory profession of them all, notwithstanding its numerous physical hardships, its grave responsibilities, and its exacting demands upon one's time and energies. Never once since graduation, over a quarter of a century ago, would I for an instant have considered any proposition to abandon the profession of my choice, and never once have I regretted that choice—this notwithstanding the fact that my early experience was anything but an easy one, involving as it did small pay, excessively hard work, long hours, continued exposure to rain and snow, occasionally extreme hunger, unappreciated effort, and sometimes imminent peril to life. Many of these things at the time

were intensely disagreeable; but now I look back upon them with great satisfaction, feeling that they were indeed blessings in disguise. Hard knocks tend to develop a man and to bring out the best that is in him; hence if in the near future any one of you have occasion to feel that the world is treating him badly or that he is "out of luck," he should not worry about it, but should proceed upon the even tenor of his way, having confidence that all will come right ere long, and that later he will have occasion to feel thankful for all his unpleasant experiences.

The question that naturally interests you most just now is what work you will start with and possibly what compensation you will receive; hence a few suggestions from an old fellow who has been in harness for many years will perhaps be acceptable.

It is far more important that you obtain good experience than that you receive at the outset a large salary. The services of a newly-fledged engineer are as a rule of little or no account. On some work they have a positive value, on other work they are worth zero, and on still other work they have a negative value. The higher the branch of engineering that the recent graduate enters, the less valuable to his employers will be his services. For instance, in any work of surveying the young engineer from the very first day can earn as much as a teamster, axeman, rodman, or general roustabout, and in a few weeks considerably more; in more complicated work, such as waterworks, sewerage, or railroading, for a few months at least, the value of his services will be approximately zero; while in extremely complicated work, such as bridge designing, the drafting that he does at first either has to be done all over again, or requires so much time for correction as to render it practically worthless; and at the same time he occupies the attention of those whose services cost considerable money and who possess large earning capacity. In our office we estimate that it takes three months to bring the value of the recent graduate's services up to zero, and three months more to recoup the office for its loss on his instruction; hence it is not until after six months that his work really begins to become remunerative.

Each of you must judge for himself what class of work is best suited to his needs and conditions. Fortunately for you, it is practicable today to enter any branch of engineering that you may choose, as engineers of all kinds are in great demand, everybody having more work than he can really do in the short time that is almost invariably allowed on the engineering portion of enterprises.

Some of you are perhaps in need of money, possibly to pay debts incurred in obtaining your education. These I would advise to take positions on railroad surveys, where good salaries are paid at the out-

set, and where up to a certain point promotion is rapid for a man of the right type. Or if field work be not to your taste, comparatively large earnings can be made at once by entering as draftsman the employ of a bridge manufacturing company. Here the promotion is slow, and the professional advancement is still slower, as it is naturally to the company's advantage to keep a man continuously at one kind of work as soon as he becomes proficient in it. Comparatively good positions can be obtained by joining the engineer corps of a large railroad company, and working up step by step; but the progress is slow, and the plums that can be reached at the top of that tree are only two or three in number.

It is not a bad idea to take a subordinate position in some large manufacturing concern, and work up; for there the possibilities of promotion are better, and there is always a chance of making your services so valuable that you will eventually be taken into the company.

Government positions are fair enough in a way; but they are difficult to obtain, and do not offer much of a field to an ambitious man. About the poorest and most unsatisfactory position that one can take is in the employ of a city, not only because the pay is generally small, but mainly because the tenure of office is so uncertain. Believe me, I would prefer a position as boss grader on a dump to that of city engineer, and I would rather work as a navvy with a pick and shovel than accept a subordinate position in the engineering department of a city. Avoid all political positions; they are badly paid, insecure, and in every way unsatisfactory. It degrades a man, in his own estimation at least, to feel that he is at the mercy of every log-rolling, wire-pulling ward-politician who may for any reason take offense against him. Engineering positions in municipalities ought to be placed above the control of politics; but how to accomplish such a *desideratum* is more than I can suggest.

As far as the attainment of knowledge and ultimate high advancement are concerned, the best positions to take are those in the employ of consulting engineers of established reputation. Ordinarily these are very hard to get; but at present it is otherwise. In England a young man has to pay handsomely for the privilege of entering such an office and working there for several years without any salary whatsoever; but this custom does not exist in America, owing to the fact that such good training is given in our technical schools.

No matter what branch of engineering you choose, aim always to obtain valuable experience rather than large pay; the latter will follow as a matter of course after the former is acquired.

If I were once more a young man just leaving my *alma mater,* and if I were not cramped for means, I would, for at least five or six years, work in subordinate capacities, for a few months at a time in each position, leaving just as soon as I had mastered the principal engineering features of the work, or just as soon as the daily attainment of knowledge failed to satisfy my desire, and taking up another line of work, in order to secure for myself a sound, practical knowledge of a number of branches of engineering. Meanwhile, I would be deciding on my specialty and gradually turning my energies towards the chosen line of work, to the ultimate exclusion of all other lines; and I would not rest content until after I had acquainted myself with every minor detail of my adopted specialty, so that, after settling down to a private practice of my own, I should feel master of the situation on each new piece of work as it comes up, and should never have any reason to fear that my ignorance of any detail would prejudice me in the opinion of my clients. It would take courage and plenty of it to follow such a course as this; but the ends to be attained would be worth the effort.

It is a great mistake for a young engineer to choose a specialty before he has had several years of general experience. What a source of dissatisfaction it must be for a middle-aged man to feel that he has chosen the wrong line of work, and that it is too late to make a change!

It is possible that I am wrong in giving you advice based upon the supposition that you all desire intensely to rise high in the profession, and that you will eventually reach the top of the tree. It is true that all cannot be first and that all have not equal ability; or, to quote the sentiments if not the exact words of a poet who is today almost forgotten,

"Order is Nature's law, and this confessed,
Some are and will be greater than the rest."

Nevertheless, in my opinion, it is better to strive constantly for a high ideal and fail to attain it completely, rather than to jog along contented with small things and mild ambitions. At any rate, the actual results attained by the former method are almost sure to exceed materially those accomplished by the latter.

From personal experience, I can assure you that it is within your power to attain ultimately your heart's desire for professional advancement and distinction, no matter how lofty your ambition may be, provided that you strive for it faithfully and never despair. To be a successful engineer, one should establish in his own mind (and generally keep them strictly there) certain objects to be attained in both the immediate and the distant future, adding to them from time to time as his experience increases, and never resting content until they are accomplished. Earnestness of purpose is a *sine qua non* for success; with-

out it one may as well consider himself at the outset out of the race. Above all things, don't work by the clock and quit the moment time is up; for if you do, you will soon establish for yourself with your employers and associates the reputation of being a mere time-server. I have on several occasions seen a navvy with a pick poised for a blow, drop the tool upon the first blast of the whistle announcing quitting time. Such an action may be excusable in an ignorant workman, but it would not be so in a member of the civil engineering profession.

Some engineers pay their assistants for overtime, while others do not. I have tried both ways, and am able to say which is the better method; and this is my judgment: The overtime system is more satisfactory to the average draftsman, and at the same time is really better for the employer; because he then pays for only the hours actually spent on the work, counting out all lost time, and because he feels no hesitation in asking his men to work nights and even Sundays when occasion demands. Nevertheless, I have noticed that the young engineers who have risen the most rapidly are those who have never been paid for overtime; and this stands to reason, because an employer of the right kind feels that in common decency he must promote rapidly any employee who shows such an interest in the work as to labor overtime without thought of extra compensation.

In all your work cultivate to the utmost the attributes of reliability and accuracy, and never let any computations be used unchecked, the checking being done either by an independent computer or by an entirely different method of figuring. I cannot impress upon you too earnestly the importance of a thorough check on all work. Without it, mistakes, and sometimes serious ones, are sure to occur, for the man who makes no mistakes is the man who does no work.

Some students of technical schools look down upon drafting as being *infra dig.*, and think it not worth while to perfect themselves therein, assuming that immediately after graduation they will obtain positions outranking those of draftsmen. No greater mistake than this can be made. If any of you have gone through school with this idea in mind, I advise that before beginning actual practice you take a post-graduate course in the mechanical part of drafting. It is by no means enough to know how to outline a design; it is absolutely essential that you be able to finish the drawings neatly and thoroughly, so that the blue prints made from your tracings will be a credit to the office where they were prepared. Drafting is by no means beneath the dignity of an engineer, and unless he be truly proficient therein he is likely to fail to attain success.

This reminds me of an amusing incident that occurred the other day in my practice, and I shall relate it as an illustration of the point I am trying to make.

A middle-aged engineer of considerable experience but who was temporarily out of work, applied to me for a position in our office, volunteering several times the information that he was an engineer and not a draftsman. He dwelt so much upon this point that I felt constrained to inform him that nearly all the draftsmen in our employ were engineers and several of them very good ones indeed. Although sadly in want of office assistance, we had no position to offer the gentleman.

There is no part of an engineer's work that is *infra dig.*, and I assure you, young gentlemen, that there are many valuable things which you can learn from the illiterate workman who labors in the ditch with his pick and shovel, or who mixes concrete on the platform. There is no part of construction work that is of too menial a nature for you to learn. Knowledge of every kind will stand you in good stead sooner or later. There is a certain amount of drudgery that all have to do, and it should always be done willingly and good naturedly. The harder you work on it, the sooner it will be finished; therefore get right at it and do not shirk.

Every young engineer should make a practice of reading the leading technical papers, at first covering almost the entire practice of engineering, but gradually omitting those articles in which he is not peculiarly interested, until finally, after his specialty is chosen, his reading will cover only the items of general news and those papers which pertain to his particular line of work and thought. One must discriminate in reading of all kinds, for otherwise much valuable time will be wasted. There is certainly a deal of technical trash written; hence it is necessary to learn how to separate the wheat from the chaff.

Are some of you congratulating yourselves with the thought that your four years of hard study are at last over, and that after you enter the actual practice of engineering there will be no further need for study? If so, please proceed at once to disabuse your minds of this idea, for it is fundamentally and essentially wrong. If you fail to keep up and to carry on your studies, good-bye to all hopes for professional distinction or even mediocre success. Engineers have to be students all their lives, and the younger they are the greater their necessity for studying from books. Believe me, you have still a great deal to learn; therefore I advise each of you to devote at least one hour per day, or preferably two hours, to the continuation of your technical studies and to the reviewing of your mathematics, both pure and applied. The day when you will no longer be able to continue such studies will come only

too soon; consequently I counsel you, while you are still young, to devote to them what time you can spare.

Lay out in consultation with some professional friend a course of study in both theoretical and practical subjects, and stick to it conscientiously. Set a certain time for a certain amount of reading, and if you fail to cover it in the given period, work harder in the next period so as to catch up with your programme. No matter what your occupation may be, you will be able to find time for study as long as you continue to be an employee, because no employer can expect to occupy more than a reasonable amount of your time in excess of the usual hours of labor, even if he does compensate you for it with extra pay.

Study well the English language and obtain a thorough command of it, in order that you may be able to speak and to write it with conciseness and vigor. Perfect yourself in style by reading well written books, even if they come under the denomination of light literature. A little of the latter affords relaxation, and, when really good, can do no harm to a professional man, unless he becomes so addicted to its perusal as to neglect more important reading. Nowadays there are many American and Canadian writers of good fiction, whose command of the English language is excellent, hence, there are plenty of good, interesting books from which to choose.

As a rule the graduate engineer has no time to devote to the study of foreign languages; and it is questionable whether it be advisable to devote to them much time at the technical schools. The plea for their retention is that there are many good technical books in these languages that the student ought to be able to read. My reply to this is that there are more good technical books in the English language than a man can ever find time to study, and that all valuable technical works in foreign languages are soon translated into English. In my opinion, a knowledge of French is only a gentlemanly accomplishment, and one that a man is very liable to lose for want of use, and a knowledge of German is of no advantage whatsoever to an American engineer. There is one foreign language, though, that I believe it would be a good policy to teach to technical students, and that is the Spanish; but the instruction given in it, to be of value at all, should be so thorough as to enable each student to read, write, and speak it with ease and fairly correctly. Is such a course practicable? I answer most decidedly, "yes," but the methods of teaching foreign languages now in vogue in technical and most other schools would have to be abandoned and a more practicable method adopted instead. The reason for teaching Spanish in technical schools is that American engineers are beginning to monopolize the principal engineering positions in the Latin-American countries;

and, as the latter develop, the demand in those countries for American engineers will surely increase. A man going to such a country without any knowledge of the Spanish language is badly handicapped. Eventually he will learn by contact enough of it to get along; but owing to lack of time for study and the unavoidable disability of advancing years, he will never be a master of even the rudiments of the language. It is far easier for a boy to learn a foreign language than it is for a middle-aged or elderly man. Concerning this matter I am speaking from experience, because for the past three years a large percentage of my professional work has been located in Mexico and Cuba, and I have spent fully one-third of that time in the former country. How often have I wished that I had studied Spanish properly in my youth instead of wasting my time on Latin and Greek, both of which I have long forgotten!

In laying out a course of post-graduate study, be careful to choose only those subjects that will have a practical value, and beware of abstruse mathematical calculations, for these too often are based on false hypotheses and in consequence produce unreliable results. Mathematics should be treated as a servant and not worshipped as a god! Some men appear to think that a technical paper, to be of any account, should be filled with abstruse mathematical calculations, on the same principle which many old English writers adopted when they interlarded their writings with numerous Latin and Greek quotations, simply to show that they had received a polished education. This is all wrong; for the less mathematics a technical paper contains and the simpler the mathematics, the better, in my opinion, is the paper. Now don't go off with the idea that I am not a believer in the higher mathematics and in the necessity for their study. Although as a rule the mathematics in an engineer's practice are of a very simple and elementary character, yet there occasionally occurs a problem which will set him to thinking and to brushing up on the mathematics of his school days. It was only a few weeks ago that I ran across one of these cases, and I shall now describe it to you in order to illustrate a practical man's habit of making short cuts to obtain results.

From a point on a bridge tangent out in a river, three hundred and forty feet from its intersection with a base line which cuts it at an obtuse angle, starts a twelve-thirty curve. The problem was to locate exactly the intersection of the curve and the base line. I made several attempts by both trigonometry and analytics to get an exact equation, but each time found that I had too many unknown quantities for the number of my equations. While I was thoroughly convinced that an exact, direct solution of the problem was feasible, for lack of

time I simply fudged it by establishing an equation of only one unknown quantity, viz., the angle included between two radii of the curve, one passing through the starting point and the other through the intersection of the curve and the base line. One side of this equation involved the sine of this angle and the other side the cosine; consequently by measuring the angle very accurately on the plot and making three or four trial substitutions in the equation, I was able to obtain its true value with all the necessary accuracy. I had given the problem to one of our assistants, a bright young fellow who graduated last year from the Industrial University of Arkansas (an institution, by the way, which has turned out two or three engineers who are second to none in their specialties); and he by taking plenty of time succeeded in finding the exact equation, but it was an appalling one. Both equations were used in preparing the construction diagram, and afforded an excellent check on the correctness of the calculations.

Let me give you another example of practical mathematics. Several years ago we had occasion to send as transitman on the construction of a large bridge a young engineer new to our employ. One of the first difficult problems that he encountered was the daily determination of the various errors in position of a pneumatic caisson during the process of sinking. The mathematical problem was too much for him; and he telegraphed to our office for a demonstration. My partner replied that I was then on my way to the bridge site and would give him the information desired; hence upon my arrival I found the problem awaiting me. Hitherto I had left to my resident engineers the task of ascertaining daily the position of each caisson, and they had always solved the problem by some means or other in a manner satisfactory to themselves; consequently I had never before had occasion to demonstrate the method. I asked the young man to let me see his figures, and found that he had accumulated a mass of sines, cosines, and tangents of the utmost complication without obtaining any result. I thereupon, sat down and worked out in an hour or two a practical solution, then handed it over to him to check. He did not get very far with his figures before he exclaimed, "Here, this is all wrong. You have assumed two lines as parallel when they are evidently not so; for if they were, there would be no error in the direction of the horizontal axis of the caisson." To this I replied, "Yes, I know the two lines are not truly parallel, but how much error have I made in the demonstration by assuming them so? Moreover, granting that the lines are not even approximately parallel, the erroneously calculated error of position will be close enough for an approximate correction during the next day's sinking, and in your next solution of the problem the effect of the false assumption will be almost

infinitesimal." Since that time all of our resident engineers have been furnished with blue prints containing this "faulty" mathematical demonstration; and some day, when I have time, I am going to insert it in a second edition of De Pontibus.

It is strange what a distaste practical engineers develop for long and complicated formulæ and for making intricate mathematical investigations. This is an excellent reason for giving in technical schools thorough courses in both pure and applied mathematics, and for young engineers to continue their mathematical studies after graduation.

Every engineer should keep constantly in his pocket a note-book in which to record, as soon as he thinks of them, things to be done; and whenever he runs short of work, even for a few minutes, he should look over the list and pick out something that can be finished during the interval. As soon as one of the items has been attended to, he should draw a line through it; and when the list gets too long and too much scratched, he should transfer the remaining items to a new list and start afresh. It is surprising how much can be accomplished in this way. Some people claim that this habit is absolutely destructive to one's memory. This may be true; but it is a fact that a busy engineer's memory is the most unreliable feature in his entire constitution; hence the damage done by the note book is of little consequence.

One should endeavor to utilize all of his spare time in either work or amusement, as time simply idled away is an absolute loss to both oneself and the public. An engineer should not even understand the expression "to kill time." As I often tell people who delay me unnecessarily by failure to comply with instructions, "Time is the most valuable thing I possess, and you have robbed me of some of it by not doing as you were requested." Even when traveling one can utilize his spare time; for example, this address was blocked out on a Pullman car and written in hotels during a business trip in the South about a month ago.

It is an excellent plan for an engineer to keep a diary and record therein daily (not weekly or even on alternate days) all events of importance, work done, progress of construction, etc. Such a diary will prove of great service in many ways, especially on field work.

Every young engineer should join the leading technical society in his branch of the profession, starting in as a Junior immediately after graduation and changing grade as soon as he qualifies, until he reaches the highest. He should also take an interest in the Society's affairs and contribute to its proceedings by writing for it papers descriptive of his work, or recording the results of original investigations, or compiling scattered knowledge. Don't write until you have some-

thing interesting and valuable to present; but make it your business to find something of the kind as soon as possible.

It is a good thing for a young engineer, after he has been from three to five years in practice, to spend a year or two in teaching engineering in a technical school, for no experience can impress things on one's mind so thoroughly as does teaching; besides, a year or two thus employed offers the young engineer an excellent opportunity to make investigations based on his practical experience, thus contributing to the general fund of professional knowledge as well as aiding to establish his reputation as an investigator and a technical writer. It does not do, however, to spend many years at teaching, unless one intends to make it his life's work. No greater mistake can be made than to start teaching in an engineering school immediately after graduation. The newly-fledged alumnus is fit to teach no part of the curriculum, unless it be pure mathematics, and he could teach even that much better after having had a few years of practical engineering experience.

Every engineer who has any literary gift whatsoever should cherish the ambition to write a technical book. Good technical books are needed to-day, and will always be in demand. Their lives are of necessity short, as practice is constantly changing; but the fundamental principles of design and construction never change; therefore he who deals with these in his writings will produce works that will continue to be useful perhaps long after he has passed away.

In your practice do not hesitate to try new methods or to depart from established custom, provided that after thorough consideration you feel sure that the departure would be a wise one and in the line of improvement. If all engineers followed precedent, how little progress would be effected! Should you, peradventure, come to grief in any of your experiments or departures from the beaten track, don't try to hide your failure, but publish it generously so that others may be warned by your experience. Believe me, the confession of such a failure will not harm you in the least, but will give others confidence in your honesty and courage.

In all that you do, remember that you have the reputation of the greatest of all professions to uphold, that your integrity must ever be beyond question, and that there is never an excuse for untruth of any kind. Business shrewdness is all very well in its way, especially for those who go into contracting; but falsehood is always needless. On the other hand, an uncompromising bluntness is unnecessary; and, in dealing with people, a cultivation of policy and tact is a virtue. Because you think a man is a fool that is no reason for telling him so; and, when you see that an individual is cherishing

some pet notion which is erroneous, it is far better to lead him gently to a recognition of his error than it would be to tell him imperiously that he is wrong, or that he does not understand the matter. Policy and tact are just as essential to success in engineering as are ability, energy, and integrity. By means of the last three attributes one is enabled to do his work thoroughly and well, but it takes the two former to enable him to secure it.

Never repudiate a promise or engagement of any kind, but perform what you have agreed to do, even at pecuniary loss to yourself. If you adhere strictly to this rule, it is evident that it will be necessary for you to beware of making rash or hasty promises.

I had intended speaking to you at length upon the subject of engineering ethics, but time will not permit. It is a matter which is still in embryo. We have no established code of ethics in our profession; consequently, until the solons who are now discussing the matter decide upon one, all that an engineer can do is to treat squarely everybody with whom he comes in contact, to try to make others happy whenever it is possible, and always to act according to the dictates of his conscience.

No matter how small your earnings may be, always endeavor to save and put in bank a portion of them, for the money thus saved will assuredly prove useful some day. Avoid fancy investments of your savings and dabbling in projects that promise enormous profits. They nearly always fail, and the money invested is usually all lost, with occasionally considerably more. Engineers do not make good investors, because their attention is so devoted to their profession that they fail to obtain the necessary experience to care properly for their possessions. It is far better to invest in good first-mortgages or even government bonds than to sink your earnings in the most promising schemes. In this matter heed the advice of one who speaks from sad experience.

If one is in the employ of a good, substantial, manufacturing or contracting company, it is well to invest at least a portion of his savings in the stock and securities of that company, especially if these be offered at a low figure as an inducement to the young man to take an interest in his work. Such an investment tends to the employee's advancement, and may eventually lead to a high official position. An excellent example of the good effects of such a system is given by the Carnegie Steel Company, most of the present officers of which started in at the bottom of the ladder in the company's employ, and worked their way up by becoming stockholders. In spite of all the talk one hears about soulless corporations, good, efficient, faithful, and willing

service is nearly always recognized and retained; hence I would by no means discourage any young engineer from working for a large manufacturing company which employs civil engineers.

Make a practice of studying true economy in your designing. It is far better to build a structure which is cheap and has no pretensions to permanency, rather than a quasi-permanent one that is cheapened by ignoring the first principles of design, and that will surely wear out or fail sooner or later on this account.

The writing of specifications is one of the most difficult tasks that you will encounter in your practice. At first it will be best for you to adopt, if possible *in toto,* the standard specifications of older engineers, or use these as a guide in preparing your own, until such time as you can produce some which will be better than any others. Don't make changes, though, for the sole purpose of producing something original, but only for the sake of effecting improvements. Specifications should be clear, concise, complete, and free from all unnecessary repetition.

Study the science or art of systemization, for it will aid you materially in your practice. If it be not improper in an address of this kind for the speaker to quote from one of his own published works, I would like to repeat the following from the chapter on "First Principles of Designing" in my "De Pontibus":

"The systemization of all that one does in connection with his professional work is one of the most important steps that can be taken towards the attainment of success."

If you have the opportunity, do not fail to take post-graduate degrees or any other degrees or professional distinctions that are within your reach. They cannot possibly do you any harm, are a source of great satisfaction to the recipient, and carry weight with most of the men whom one meets.

I may get into trouble by stating it, but I am firmly convinced that early marriage is not conducive to a successful career in engineering, for the reason that it confines a young man too much to one locality and causes him to strive for the almighty dollar rather than for ultimate professional advancement.

And now before closing there is possibly an apology due my hearers for the marked personality of this address. If so, please consider the same made most truly and humbly. In writing it, I felt that I could get nearer to you all by referring occasionally to my own experience, dropping all formality, and speaking from the standpoint of a brother engineer, nor do I think that I have been wrong in so doing;

nevertheless I should not be surprised if I be criticized adversely for this, especially if my address appear later in print.

By this time you all have probably come to the conclusion that you have been listening for the last half hour or more to an old fogy, who thinks that there is nothing in life worthy of consideration but work, work, work, and who can talk on nothing but technical subjects. If this be so, I by no means blame you, for you would seem to have reason on your side; nevertheless you would be entirely in the wrong, because I am a firm believer in legitimate relaxation of every kind and in a man's getting all the pleasure he can out of life. Perhaps, too, I could talk of things that are far from technical, such as hunting the great game of the Rocky Mountains, canoeing on lake and stream, the shooting of rapids, travels in foreign countries, gunning for wild fowl in the marshes, sports afield with dog and gun, fly fishing for trout in the streams of the far North, and struggling with the gallant tarpon on the waters of the Gulf of Mexico; but it was not to discuss such subjects as these that your President brought me here, consequently I shall desist, only remarking that the more you mix these things and other sports and amusements in with your work, the better will it be for you both physically and mentally, the longer will you live, the more will you accomplish, the more satisfactory will be the results of your work, the better men and citizens will you become, and the more interesting and agreeable will you prove to all with whom you are thrown in contact.

Certainly mine has been a decidedly rambling discourse; but I hope you will pardon this feature of the address for the reason that "scattered shot hits most birds," hence perhaps I have bagged several of you with some of my pellets; while, had I used a choke bore by adhering steadfastly to one subject, I might have missed my aim altogether, or at best succeeded in capturing only one individual.

In conclusion I beg to say, gentlemen, that it has given me sincere pleasure to meet and address you; that if in the future I can serve you either collectively or individually, I shall be at your command; that I hope some of my remarks may some day prove of benefit to you, and that I wish for each one and all of you the greatest satisfaction in life—a truly successful, professional career.

GRADUATE STUDY AND RESEARCH.

By

Dr. Chas. H. Benjamin.

In the seventh paper of this series Mr. John Lyle Harrington deals at length with the question of the "Necessity for Continuing Study after Graduation," and shows conclusively that the graduate engineer cannot reach any eminence in the profession unless he continues his studies after the completion of his technical course.

The present paper by Dr. Benjamin, who is Dean of the Engineering Faculty at Purdue University, supplements most forcibly all that Mr. Harrington has said, although it is addressed primarily to those specializing in engineering education. As quite a large percentage of technical graduates spend at least a portion of their professional careers in teaching, the reproduction here of Dean Benjamin's valuable paper ought to prove well worth while.

Charles H. Benjamin was born at Patten, Maine, August 29, 1856, and received his earlier education at the Patten Academy, one of those state-endowed institutions which preceded the free high school. After having served an apprenticeship of three years as machinist in the shops of Benjamin and Allen at Oakland, Maine, he entered the University of Maine, taking a special course in Mechanical Engineering. Then, after a year or more of practical work as machinist and draftsman, he returned to the University in 1880 as Instructor in Mechanical Engineering, becoming Professor in 1883, and remaining there three years longer. He received the honorary degree of M. E. from that university in 1881.

In January, 1887, he accepted a position as Assistant Manager of the McKay Heeling Machine Association of Boston and Lawrence, Mass., having charge during that time of the factory and city offices of the Company and devoting considerable time to a review of patents on this class of machines.

In 1889 he was appointed Professor of Mechanical Engineering at Case School of Applied Science, where he remained eighteen years. During his incumbency at that institution and also at the University of Maine, he had the opportunity of planning and building new shops fot the work in Mechanical Engineering. In 1900, he was appointed by the mayor of Cleveland, Ohio, as supervising engineer of the city, having charge of the installation of boilers and furnaces for the purpose of

abating the smoke nuisance. He continued in this position two years, resigning on account of the press of college work; and in 1907, he was appointed to his present position at Purdue.

In 1908 he received the honorary degree of Doctor of Engineering from Case School of Applied Science.

He is a member of the honorary societies of Tau Beta Pi and Sigma Xi; is active member of the American Society of Mechanical Engineers, the Master Car Builders' Association, the Master Mechanics' Association, the Western Railway Club, and the Society for the Promotion of Engineering Education; and an honorary member of the Cleveland Engineering Society.

He is author of "Machine Design" (Henry Holt & Company of New York), "Steam Engine" (Technical Press), "Modern American Machine Tools" (Constable & Company, London), and "Moderne Amerikanische Werkzeugmaschinen" (Otto Spamer, Leipzig).

He has devoted considerable time to original investigation, especially to the strength of materials, including the bursting of fly-wheels, steam engine cylinders, flat plates, emery wheels, cast-iron discs, and commercial pulleys of various types. Most of this material has been published in the Transaction of the American Society of Mechanical Engineers.

Editors.

GRADUATE STUDY AND RESEARCH.

By

Dr. Chas. H. Benjamin.

On first graduating from college, the young man is sometimes inclined to believe that his education is finished and that all he has to do is to realize on his investment. If he goes into practical work outside of the University, he is soon disabused of this idea. Contact with men and things in the outer world has a tendency to convince him that his education is just beginning. If he can but succeed in establishing a connection between his college training and the requirements of his profession, he is fortunate.

The best technical schools can only give the fundamental principles of science and engineering with but a brief attempt at application. On the foundation thus provided, the graduate must build his own superstructure and must adapt his style of architecture to his environments. If he has been educated and not "filled up" or as one writer puts it, if he has been a "sponge and not a bucket," the building will be easy.

For the graduate who leaves professional life and becomes a teacher, the incentives to study and investigation are not so immediate. He is teaching the same things that were taught him and in about the same way. There are no outside pressure and competition to stir him and to spur him. The university wall and the college atmosphere deaden the sounds of traffic and bustle from without and leave him in a world of his own. Under such circumstances there is danger of stunted growth and dry rot.

In the live, progressive sciences of to-day, there is no such word as rest. The information acquired in college, like the United States Constitution, must be a rudder, not an anchor. The close contact between our leading technical educators and the affairs of the outer world is a sufficient refutation of the claim that the instruction given in our colleges is academic and not practical. When manufacturers, farmers, and business men in general come to the professors in the universities for the solution of difficult problems in their several lines of work, no argument is necessary to prove the practical worth of college trained men. These men have not become what they are by simply floating along with the current and just keeping their heads above the surface of their

every day work. The training and knowledge which command the respect of the practical man of affairs were not obtained in this way, but were the result of hard work and continuous application.

Three requirements must be met by the university man who would have the confidence and respect of his compeers outside:

1. He must have a broad culture to enable him to meet men on their own level.

2. He must have a good store of information on all subjects in the line of his profession.

3. He must know more than most other men in college or out of it, about some one thing.

As John Stuart Mill put it, (rather strongly perhaps), "He should know something of everything and everything of something." To the overworked, underpaid instructor, this may seem too remote a mirage to be worth considering. But I want to say to you right here that you must make this your goal; you must start on this way, for it is *the* way and the *only* way to professional salvation. When you spend from six to eight hours at the university each day and when you have lessons to prepare and papers to correct, it may seem that you have no time for further work or study. Be this as it may, your only chance to rise above the level of mediocrity is by independent study and research. I would not urge any man to overstep the natural boundaries between bodily health and ill health. Each must be his own judge of his physical limitations. Often a judicious admixture of physical exercise with mental application will enable one to accomplish the otherwise impossible. Systematic use of the time at one's disposal for work and for play will sometimes bring about astonishing results. If you have daily an hour or two hours at your disposal, it is remarkable how much and how little may be done in this time accordingly as you use it systematically or recklessly.

There comes a time in nearly every man's life when he finds that he can not keep up to concert pitch all the time,—that he must let the strings down a part of the day and relax a bit. To some men this comes at forty years of age, to some at fifty, and to some apparently not at all. The really hard work and close study must be done before this time and it is up to the younger man to do it. Now, what is there to be done and how is one to do it? If you are interested in your profession, you soon find something in your work which attracts you and about which you want to know more. If you do not, something is wrong; you may have mistaken your vocation; you may not have waked

up yet to its possibilities; or you may have been indifferent. When you find this thing that attracts you, study it in your spare time; go to the books in the library, to the files of periodicals and find what others have done. See if something has not been left undone that you can do, see if there is not some new avenue of approach as yet untrodden. Frequently men think and write about a subject for a long time and formulate new and ingenious theories without actually putting their formulas to the test.

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Most things are as yet undiscovered; and we are just chipping at the shell of the egg. It may be for you to make a discovery which shall revolutionize theory and practice in some department of knowledge.

Have a card index of your own where you may jot down in order references to articles in the scientific periodicals which interest you. No printed index will take the place of this; such are too voluminous; and, besides, the title of an article often gives no clue to the paragraph or the illustration which you want.

Make it a point to visit the library once a week and skim the periodicals which appeal to you. Read an article when you can, but do not fail to sift them all and index what you may use at some future time. You must keep abreast of the rapidly advancing tide of thought and action in your line or you will soon become a mollusk in the sands of yesterday.

Get in touch with your fellows in the campaign of investigation. Join one or two societies, attend a meeting now and then, and become personally acquainted with the men who are moulding opinion in scientific lines. When you have done something which is worth while, write a paper and present it at a meeting of your society. Be modest in your statements, sure of your facts, and firm in your opinions.

Theories are like weeds—they grow best where there is no other crop. Facts, as determined by experiments, are more rare and command a good price even among experts.

One who confines himself entirely to the narrow path leading from his boarding place to his class room becomes in time just an eating and teaching machine. Such narrowness of application defeats its own object: the teacher who knows only what is between the covers of the text-book is an unsafe guide.

Character and reputation are the principal assets of the teacher, and the latter is the only one on which he can realize.

It is by graduate study and research and by the presentation of the results before scientific societies that the younger man becomes known

to the world. You may call this advertising, and so it is; but there is nothing disgraceful about advertising when you really have the goods. If a man has a horse to sell, he must go to market or advertise.

I have not said anything about private libraries and I hesitate to do so. A good library is more to be desired than great riches; unfortunately, unless you have the latter, you may not possess the former. I should advise the younger man to go slow in the purchase of books, especially if he have access to a good reference library. Scientific books come high, and in many cases you have to pay for a lot of padding. When a writer collects a number of moss-grown formulas, stirs them up with an assortment of cuts and descriptive matter scissored from recent catalogs, and sells the result at $6.00 per, it is time for the buyer to stop and reflect. Buy only the books which you feel you must own; and when in doubt, recommend them to the University librarian.

THE NEED OF GRADUATE COURSES IN ENGINEERING.

By

Hon. Willard A. Smith.

This address was delivered in February, 1908, at the installation of Dr. W. F. M. Goss as Dean of the College of Engineering of the University of Illinois. It is teeming with great thoughts and words of wisdom; and it cannot fail to meet the hearty approval and endorsement of all thinking men who read it. Although its author had probably never seen the following address on "Higher Education for Civil Engineers", this discourse endorses the stand taken by the writer of that paper in making his plea for more extended technical education for the chosen few who are to advance the engineering profession by their scientific and technical researches.

As Chief of the Department of Transportation Exhibits at the World's Fair in Chicago, 1893, Mr. Smith made the first transportation exhibit ever got together at any exposition. The work was entirely new and without precedent. A very complete graphic history of transportation in all its forms was made by means of models; and actual examples were gathered at considerable expense from all quarters of the globe. The then "present state" of transportation was also illustrated by exhibits occupying a large building and considerable out-of-doors space. The importance of the department and its novelty are illustrated by the fact that it was the only department of the exposition which was the subject of an entire book. (See Transportation Exhibits at the World's Columbian Exposition, 1893, by Jas. Dredge, Editor of "Engineering," London, Eng.) An important fact in this connection is that, for the first time, European locomotives, cars, track, etc., were shown alongside the American, so that the differences between them could be clearly seen and studied. English, German and French track and complete trains were secured by Mr. Smith by personal work in those countries, notwithstanding the fact that it had been repeatedly stated that the task was impossible of accomplishment. Mr. Smith also secured large and important exhibits of the engineering societies of Germany, of the British navy and merchant marine, etc.

At the Universal Exposition of Paris in 1900, Mr. Smith was Director of Transportation and Civil Engineering for the Commissioner General of the United States. He secured representative exhibits and ex-

pended large sums properly to represent to the European World American engineering in its various branches. The awards secured were very flattering to the United States. As delegate of the Department of State of the United States Government, he represented this country in all of the engineering congresses held in Paris during that year.

He accepted an appointment as Chief of the Transportation Department of the Louisiana Purchase Exposition at St. Louis in 1904, with the hope and for the express purpose of demonstrating the feasibility and value of testing locomotives on a stationary plant. After several failures to secure the large sum needed to do this, he interested the Pennsylvania Railroad Company in the plan. They expended upon this, first and last, the sum of $250,000. American and European locomotives were tested on this plant; and the volume published by the Pennsylvania Railroad after the close of the exposition attests the value of the work and its far reaching influence on the engineering of the future. The whole work was carried on under the advice and supervision of engineers appointed by foreign countries, and by the American Society of Mechanical Engineers and the American Railway Master Mechanics' Association. The transportation exhibit at St. Louis occupied a building covering sixteen acres of floor space and some additional space outside. It hardly seems possible that a larger transportation exhibit will ever be made, or one with more lasting results on engineering. A description and record of this exhibit were also published in the form of a large volume with over 700 original illustrations.

Editors.

THE NEED OF GRADUATE COURSES IN ENGINEERING.

By

Hon. Willard A. Smith.

The world is constantly bidding higher for men of great ability and thorough training. Especially is this true of our own country and of the combination of the engineer and the man of affairs. Our enormous undeveloped natural resources, the wasteful methods which have prevailed, and the vastly increased returns from industry due to new methods and to more thorough organization, all tend to make the best ability the cheapest. The highest price has always actually been placed upon the man of business ability, the capable man, the man of tact, of initiative, and hence of mastery. This ability, which can hardly be described by a single word, is undoubtedly inborn; there are those who never can possess it. Sometimes it is early in life, sometimes late, that this sort of man finds himself. We are pointed to these successful men as evidence that higher education and especially technical training are unnecessary; but it is seldom that one of them is found who does not concede that such education would have been of great value to him. Certainly the man most in demand to-day is the one who combines thorough training with natural executive or administrative ability.

Engineering has had many definitions, most of which qualify and enlarge rather than actually define. In a very real sense we may speak of it as the science of economy, of conserving the energy, kinetic and potential, provided and stored up by nature for the use of man. It is the business of engineering to utilize this energy to the best advantage, so that there may be the least possible waste. Nature has stored up combustibles in the shape of coal, oil, and wood, the force of gravity in running or elevated water, the force of the wind, solar radiation, tidal power, and animal or muscular energy. These are the materials of engineering, to utilize which to the best advantage calls for the best preparation possible for the engineer to attain. With the lavishness of newness, little reckoning our rate of development and its terrible destructiveness, we have gone on in this country along the lines of least resistance, until the end of some of these resources is almost in sight. The President has called a conference of the governors of the states to consider what can be done towards conserving the coal deposits, the forests, and the water supply, all of which are disappearing with startling rap-

idity. The common weal calls for engineers prepared to meet the situation, for men who shall know how to make every possible unit of energy useful by improved machinery and methods, who can substitute other sources of energy for those that are vanishing, and who can plan and organize a general policy looking to the largest immediate returns without sacrificing the future of the race.

Our country calls for such men and they are needed in the councils of the nation. The business man has broken into the preserves of the lawyer in legislative halls and administrative offices. Why should not the "live-wire" engineer be there also? Why should he not be a maker of policies, instead of a mere technician, retained to work disadvantageously under the direction of the incompetent? We sadly need in public affairs some of these qualities which he must possess and cultivate. The engineer must be an accurate man; he must know his data and his formulæ, and his calculations must be exact. He is needed in politics to combat its dishonesty and slouchiness of thought and method. The engineer must be honest with himself, a kind of honesty all too rare. These qualities fit him rarely for the consideration of problems of national import which are not usually considered as engineering. The engineer's habits of thought, carried into political economy, may make of it a higher grade of engineering. Albert Fink, the great civil engineer, spent his maturest years in organizing and directing the railway traffic associations of the country, eliminating waste and dishonesty, and endeavoring so to unify the great volume of transportation that it might give the public the best service at the lowest cost, and yet permit railways to make such earnings as to insure further development. In this work, he often told me, he was still the engineer. He had graduated from one life class to another, finally reaching, as he deemed it, the highest field of engineering.

Such an engineer will not be content with simply estimating the constructive possibilities of any proposed physical development. He will examine into the actual necessities for it and the probabilities of adequate return, considering that the public money should not be sunk merely for the benefit of speculators and contractors or to promote the fad of a class of engineers. For instance, there is now before the country a proposition for the investment of enormous sums in the improvement of waterways. These are advocated by three classes, men having an itch for figuring in the public eye, politicians seeking an issue to justify their existence, and engineers interested in the technical features of the proposed work. So far as I can see, there has been no careful investigation of the traffic which can possibly be developed; and in most cases it is not only now an unknown quantity, but the conditions

for future development are utterly lacking. Ought not the ideal engineer to be an economist who shall dare to say when engineering development ought not to be undertaken as well as when it ought?

Among modern conditions which are changing the aspects of life and calling for higher engineering, I may mention the increasing congestion of people and traffic in large cities. All of the efforts to provide adequately for this, by building on the surface, overhead, and underground, have failed to keep up with the increasing congestion. The problems of transportation, and indeed of life, in the great centers of population offer an ever-opening and expanding field. Higher engineering will some time bend its energies to plans for dispersing the activities of cities, rather than to devising means for increasing the problem.

How shall we get the men to handle such problems? If the material is right, are they adequately started in life by the ordinary undergraduate course in engineering? In the elementary and secondary schools their effort has been dissipated and attention distracted by too many subjects and an entirely superficial teaching. They come with no habit of accuracy of thought or adequate comprehension of its importance. It is well if this can be instilled into them in the four years of undergraduate class-work; and if at the end of this course they are beginning to know themselves. This, for most, will end the student preparation. The genuine engineer, like the genuine man in any walk of life, will be preparing all his life. Each achievement he will value not merely for the wealth or glory it brings him, but as a preparation for something beyond. He who has got through all preparatory work is dead. I am convinced that the best results from a graduate course would come if a few years of practical experience intervened after graduation. That, however, will be subject to individual conditions, and will not influence the course itself. It is only in the graduate course that the true university methods, which have proved their value for men, can be employed. I take it for granted, also, that the graduate course will involve a correlation of such subjects as political economy and administration; so that it will start the student fairly on the road to that higher engineering career which I have endeavored to outline. A career is for "those who prove leaders, who occupy, sooner or later, positions of responsibility, develop their own methods, and may claim credit for the results achieved." It is something above the mere business or professional life.

In the graduate school it is possible to make a study of each individual student. Dr. Harper said, "Every student should be treated as though he were the only student in the institution." There also the faculty, relieved from much of the drudgery of instruction, may

carry on that equally important, nay, most important, university work, research and investigation, a work of unlimited public value of itself, and affording an inspiration, otherwise unobtainable, to the entire school. The modern university is properly gauged as much by the studies and productions of its head professors as by the men it turns out from the graduate courses.

We have not yet as a nation arrived at any plan which insures that the country's affairs shall be conducted by the fittest men. Toward that goal we trust we are tending slowly, but amid constant discouragement. One constant forward movement is in the university work of supplying men who are fitted to be leaders. Engineering education has been almost the latest to enter the university field and take its place along side the older schools. It has justified its assumption of an equal rank by what it has done so far. This higher step, taken in due time, is required if it is to maintain its dignity and enter the open door which has been set before it.

HIGHER EDUCATION FOR CIVIL ENGINEERS.

By

Dr. J. A. L. Waddell.

This address was delivered in April, 1904, to the Engineering Society of the University of Nebraska. While it was written specially for presentation to engineering students, the subject is one that apparently is better fitted for an address to engineering instructors; nevertheless its author made no mistake in preparing it; for quite lately Prof. Geo. H. Morse of that University stated in print that "To Dr. Waddell's lecture, delivered before the Engineering Society of the University of Nebraska, on 'Higher Education for Civil Engineers' may be traced the inception of the six year engineering course in this University."

That the author's idea of a great post-graduate school for engineers was not in the nature of a pipe-dream is shown by the fact that within a short time there has been established at Harvard University a post-graduate school of engineering.

Editors.

HIGHER EDUCATION FOR CIVIL ENGINEERS.

By

Dr. J. A. L. Waddell.

YOUNG GENTLEMEN:

The subject of my remarks to-night is "Higher Education for Civil Engineers." Perhaps it is not the most suitable topic possible for an address to an assemblage of undergraduates, being more appropriate for a meeting of the Society for the Promotion of Engineering Education; nevertheless, I trust that it will interest you, for it treats of a matter of vital importance to the engineering profession, of which you are soon to become members.

It has been my good fortune and my pleasure often during the last twenty years to meet and lecture to the undergraduates of engineering schools; and on such occasions when the address was of a formal nature I usually confined my remarks to advice concerning young men's work both at the technical school and during the early years of practice. My reason for departing from this custom to-night is that I have about exhausted that subject, and do not desire to repeat myself.

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In connection with my subject the first question that is likely to enter your minds is whether any education higher than that now given to civil engineering students in the leading technical schools is really necessary or advisable. To this I answer "Yes—most decidedly yes." Perhaps a few of the engineering educators will disagree with me; but I know that some of the leading ones do not.

On this question I ought to be an authority; for not only does my firm employ constantly new graduates of technical schools from all over the United States as well as from Canada and Japan, but during my travels, which average in amount about fifty thousand miles per annum, I meet a great number of engineers with whom I discuss such matters as technical education. Nearly all of them have complaints to make concerning the deficiencies in the training of the recent graduates of technical schools.

By this they do not mean to convey the idea that engineering education has been deteriorating. Far from it! For the old engineers all recognize that since their college days great improvements therein have

been effected, especially during the ten years that have elapsed since the inauguration of the Society for the Promotion of Engineering Education, to which most of this advancement is due.

But, great as may have been the strides in engineering education, the advance of the science and art of engineering has been far greater; and this divergence of progress is steadily increasing. The mass of technical literature which is of value to engineering students is now immense, and is constantly augmenting; while in my student days it was difficult to find enough good technical works to furnish us with proper text books for our course. Because of this accumulation of valuable engineering literature it is practicable to-day to give far better technical courses than were possible formerly; but the possibilities of improvement are by no means limited to results obtainable from the increased and improved engineering literature, as the latter is always of necessity far behind engineering practice.

While it would, no doubt, be impracticable to give engineering courses so closely in touch with current practice that they would make the students perfectly familiar with all of the latest developments in engineering, still it is possible for the faculty of a technical school to approximate to this *desideratum* by launching out ahead of the technical literature and securing for their students the latest information directly from practicing engineers. This procedure is certainly the most effective one possible for advancing the interests of engineering education.

It may be claimed that those engineers who complain of the insufficient training of recent graduates are merely cranks who are asking for the impossible, and that they would not be satisfied with any attainable training; but this is not true. Those of them whom I have in mind just now certainly stand at or near the head of the profession, and are reasonable, practical men. Complaints of this kind are not made ill-naturedly; but merely to state existing conditions that require betterment. Moreover they are a good thing for our profession; because if there were no tendency for the practicing engineers to make such complaints, it would indicate that perfection has been reached in the technical schools, which is certainly not the case.

Having spent six years of my life in teaching civil engineering, I naturally take an intense interest in everything relating to the development of the pedagogical branch of our profession; and I make a point of meeting the professors of civil engineering whenever I can during my travels. In conversation with these gentlemen I often suggest improvements and reforms in technical education; and they nearly always agree that my suggestions are good but state that there is not

sufficient time available for their adoption. That this is generally true I know only too well. Seventeen years ago in an exhaustive paper on Civil Engineering Education I advocated the adoption of five-year courses in civil engineering, and I have been harping upon that idea ever since. The time is surely coming when all first-class courses in civil engineering will occupy five years; and the day for inaugurating this change is not far distant. Its approach is heralded by the post-graduate courses that are becoming so common in technical schools; and the next advance will be to make these courses obligatory instead of optional.

Probably the first institution to inaugurate this change will be McGill University; for, unless I am decidedly mistaken, the faculty of that school is bending its energies toward the accomplishment of this purpose. It will then seem odd to see Canada leading the United States in such an important matter as engineering education. In truth, I am almost convinced that such is the case to-day; for the engineering course at McGill has for some time been rapidly and steadily improving. This much I can vouch for—the course in bridges is far in advance of any similar course given in the United States, or for that matter anywhere else in the world.

One objection raised to increasing the length of engineering courses to five years is that such action would work a hardship on many worthy young men of scant means and would render it impracticable for them to secure a technical education. Such a plea is a fallacy; for young men would still find some school where four-year courses are given; as to-day there are institutions where engineering is taught in three years. Again, if an impecunious young man can raise the money required for taking a four-year course, by a little extra effort he can probably raise enough for a five-year course. Moreover, it is constantly becoming easier for poor but worthy young men to secure financial aid in obtaining education.

Here let me digress a moment to make the statement that there is no better way for a financially successful man to aid mankind than by helping ambitious young men to secure thorough, practical education. Nor need such aid be given in the form of charity; for if the young man be honest as well as capable and energetic, the money can be lent instead of given him; and for several reasons the former method is decidedly better, principally because it does not injure the recipient's self-respect. By accepting notes at the current rate of interest for all moneys advanced and securing the loan by life insurance, the possibility of loss to the lender is reduced to a minimum. I have seen this method tried with fortunate results; and I recommend it to those successful men who desire to help others by the use of some of their ac-

cumulated wealth. The satisfaction that they will experience in the success of their *protégés* will transcend that from any other investment.

Among the most important deficiences noted by practicing engineers in the recent technical-school graduate are inability to express himself correctly and forcibly in either writing or speaking, lack of all ideas of system, inaccuracy in computations, ignorance of money values and economics, slovenliness in drafting, ignorance of what a drawing should contain to make it complete and serviceable, failure to understand the practical application of what he has studied in his technical course, and unacquaintance with numerous little practical things that he ought to have learned.

In commenting upon the current practice of instructing engineering students and its results, I desire you to understand clearly that my remarks are absolutely of a general nature, and refer in particular to no one institution of learning. And I especially want you to bear in mind that I have no intention of criticising the work of your professors. Of this you will probably hold me guiltless, when I confess to you that, much to my regret, I have never had an opportunity to learn anything concerning the character of the work done at the Nebraska State University.

That the study of the English language is sadly neglected in our technical schools nobody is likely to deny; for the English spoken by the majority of their graduates is atrocious; their letters are awkward, misspelled, and ungrammatical; and their ability to write reports, specifications, and contracts is practically *nil.*

Why should such a sad state of affairs as this exist, and with whom lies the blame? These questions are not difficult to answer.

The boys that enter technical schools are generally not well prepared, and the study in which they are invariably weakest is the English language. Most of them from early association speak ungrammatically, and but few of them have had proper training in spelling, grammar, and composition. Even the special preparatory schools fail to provide proper training in these essential studies; and the waiving of entrance examinations to technical institutions for graduates of such preparatory schools augments the trouble. Most technical schools give, or pretend to give, more or less instruction in English; but the courses are usually confined to the Freshman year, and are looked upon by the students as of minor importance. The result is that they are neglected, and the boys make a point of studying for them only enough to pass; consequently, when it comes to writing anything original they fail to do themselves credit.

The study of English should be continued throughout the entire technical course, and should be carried even into the graduating thesis, making its proper wording and grammatical construction essential for graduation. Too much stress cannot well be laid on the importance of a thorough study of the English language. Given two classmate graduates of equal ability, energy, and other attributes contributory to a successful career, one of them being in every respect a master of the English language and the other having the average proficiency in it, the former is certain to outstrip the latter materially in the race for professional advancement.

Upon whom then lies the blame for this undesirable state of affairs? Primarily, it is upon the faculty for not insisting that the subject of English be given as much consideration as any other subject in the entire course; and, secondarily, upon the students for their flagrant neglect of this vitally important study.

Is it not generally acknowledged by all members of the profession, young and old, experienced and inexperienced alike, that the most eminent engineers are not those who have merely constructed large and important works, but those who in addition have by their writings recorded the results of their efforts and thus instructed others concerning how to undertake similar constructions? Such being the case, is it not evident that a complete and thorough mastery of one's native language is essential to the highest professional success?

Ponder seriously upon this matter, my young friends, and see whether you do not agree with me concerning the importance to each of you of a thorough and fundamental knowledge of your mother tongue; and if you do, take without delay the necessary steps to secure such knowledge.

Both the teaching and the learning of systemization at school are certainly extremely difficult; nevertheless, a certain proficiency therein may be attained by the students, if the professor will lecture to them on the subject; but each student should endeavor to perfect himself by spending a portion of one summer vacation in the office of some engineer, contractor, or company that is noted for the effective systemization of its works and records. When there, not only should he master the subject in all its details, but also he should make full notes upon it for future reference.

Accuracy and neatness in computation can be attained in the technical school if the professors are themselves accurate and neat in their work, and if they will invariably insist on their students being so. Most young men think that if they understand the method of solving a problem that is sufficient, even if the result be incorrect, and that it is a

waste of time to check and correct calculations. No greater mistake could be made. No engineer can be truly successful who does not have all the work for which he is responsible checked and counter-checked, preferably by independent computers; and the man who fails at college to gather up all the loose ends and to make sure that no errors exist in his computations is not at all likely to develop into a careful and accurate practicing engineer.

Some students think that at school there is no necessity for dealing with dollars and cents, leaving such material things for their subsequent practice; and too often the professors either tacitly agree with them in this notion or else fail to correct the error.

Never probably since the days of the Pharaohs, when with slave labor those rulers built the great pyramids, has it been possible to divorce engineering from pecuniary consideration; and nowadays engineering, economics, and financiering are so closely allied that it is impossible to separate them on work of any magnitude. Consequently, the much despised but almighty dollar should make itself conspicuous throughout every practical course in an engineering curriculum. Students should be forced to prepare with each of their designs a complete and minutely detailed estimate of cost, and should be made to understand that this is one of the essential features of the course of instruction.

A study of the principles of economics in all departments of designing is essential to every first-class course in civil engineering; and the students should be made to comprehend that the most successful engineer is he who can accomplish a certain result in a perfectly satisfactory manner with the least expenditure of money. Care should be taken to distinguish between true and false economy, and to instill into the students' minds the principle that the most economic construction is not that which at first costs least; but that which will do its work for an indefinitely long time, and in which the first cost plus the capitalized cost of maintenance and repairs is a minimum; also that it is better engineering to build a cheap, temporary, yet perfectly safe structure with the intention of replacing it later by a permanent one, than to construct a weak or scamped structure that has a false appearance of permanency.

The character of the drafting done by the average graduates of technical schools is decidedly below par; and there is no good excuse for this, because with very few exceptions, students can be so taught the mechanical part of drafting that their efforts would pass muster in the offices of civil engineers and contracting companies. The ability to make neat drawings immediately after leaving school may mean many

dollars in the pocket of the young engineer, which otherwise would not find their way there; and in truth it may often prove the cause of his being retained in a competition for a position with otherwise better equipped men. Fancy work is neither called for nor desired; but neat, plain work, especially free-hand, is of the utmost importance.

Very few young engineers, and, truth to tell, not all old ones, appreciate how complete every drawing should be made and what written notes it should contain. In our office we aim not only to indicate on all drawings every measurement necessary for construction, but also to write on them all special instructions for the contractors and generally a condensed specification. Such drawings prevent the contractors from being able to excuse themselves for an error by saying "We did not have the specifications at hand when we were doing the work," or "The specifications are so voluminous that the clause pertaining to this special point escaped our notice."

One of the greatest difficulties under which many engineering students labor is their failure to see the practical application of theory to actual engineering. The blame for this generally lies with the professors, who either are themselves ignorant of such practical application, or neglect to call the attention of their students to it. The remedy for the evil is to insist on the professors of technical schools being practical engineers as well as good teachers.

There are numerous little practical ideas, time and labor saving devices, and short cuts to results which a practical and experienced engineering professor can present to his students, and which will tend greatly to the amelioration of the characteristic greenness of the recent graduate when entering upon his professional career.

In addition to the subjects covered in the usual curriculum of the civil engineering school there are others of great importance that are either given nowhere or are inadequately treated in a few of the schools. Prominent among these are the following: Political Economy, Law, Business, History of Engineering, Oratory, Debating, Dictation, Specifications and Contracts, Graphics, Secondary Stresses, Economics, Science of Railroading, Geodesy, Least Squares, Instrumental Work, Architecture, Geology, Tunneling, and Dams. To this list might be added some other subjects which are often given, but which are capable of considerable extension; for instance, Metallurgy of Iron and Steel, Harbors, Canals, River Improvement, Sanitation, Water Supply, Power Transmission, Highway Engineering, Mechanical Engineering, Electrical Engineering, and Reinforced Concrete Construction.

Both lists are, no doubt, very incomplete; nevertheless they are amply large to show that there are many important branches of our

profession which are either taught inadequately or are not taught at all in the technical schools of America.

But—some of you will remark—"Is it necessary for every engineering student to learn all of these branches? Surely in his active career he will confine his attention mainly to two or three lines, and in consequence will not need much instruction in the others!"

To this I would reply, "Certainly, no man can specialize in many branches of engineering work; but the student of a technical school does not know for which lines he is fitted or which specialty circumstances may induce him to adopt. Moreover, every specialty in engineering is more or less closely allied to all the other specialties; consequently it behooves a broad-gauge engineer to become somewhat familiar with all branches of engineering so as to act intelligently when his business involves him in other specialties than his own."

As an example of how the various branches of engineering are interwoven and allied, I would call attention to the facts that the bridge specialist in designing movable bridges always encounters mechanical engineering and sometimes electrical engineering; on the approaches to bridges he includes railroading; in the pavements of wagon bridges he touches upon highway engineering; in the protection of structures he meets with river improvement; in the machinery houses of swing spans he includes architecture; in the guarding of bridges against fire he encounters water supply; in the switches, signals, and interlocking plant for movable bridges he meets with a special department of railway work; and in the testing of materials for superstructure he encounters chemistry and metallurgy. That this statement is no exaggeration my present work will bear witness, for my firm is to-day engaged on the designing and supervision of construction of a number of bridges in which all of the lines of work just mentioned are involved.

As another example, the railroad engineer encounters hydraulic problems in bank protection and pumping plants, architecture and structural engineering in round-houses and other buildings, sanitation in station-houses, bridge work in the structures for his line, mechanical engineering in interlocking plants, electrical engineering in repair-shop machinery, and highway engineering where his line passes through large cities.

Again, the hydraulic engineer trespasses on the ground of the architect in his power buildings, and on that of the structural engineer in the steel roof-trusses for them, encounters mechanical engineering in his pumping machinery, and has to fall back upon chemistry in testing the qualities of water.

There is no need for further illustration; for enough examples have been quoted to show that all the main divisions of engineering are inter-dependent and inseparable.

Now while it is eminently proper, and in truth necessary, for a specialist to call to his aid experts in other lines when his practice involves engineering in other branches than his own, it is highly inadvisable that he be absolutely ignorant of everything in those other lines. Surely he ought to understand the fundamental principles which govern the engineering work therein, even if he has to entrust the details to his associated engineers!

But how can a man become acquainted with all branches of engineering? Certainly not by attending the technical schools with their present curricula, nor by endeavoring to practice in the various branches. The brevity of life makes these methods impossible at present, although it might not have done so twenty-five or thirty years ago, when the amount of accumulated knowledge concerning engineering was ever so much smaller than it is to-day.

It is true that but few young men would be willing to study enough to post themselves on all of the main branches of engineering; and in fact the large majority of the students of technical schools appear to believe that the shorter and easier the course leading to their degree the better for them. Nevertheless, there are almost invariably in every class a few who are eager to secure a broad and thorough education in spite of all the labor involved in attaining it; and it is a matter of serious regret that such men cannot now accomplish their desire.

Can there be evolved any means for enabling these young men to satisfy their praiseworthy aspiration? Yes; and later on I shall indicate it to you; but first let us consider what can readily be done to make more practical and thorough the courses given today in the principal technical schools.

Much could be accomplished by raising the requirements for entrance so as to ensure that each member of the Freshman class is fairly well posted in English and the other studies usually included in an ordinarily good American education. He need not be a master in all these lines, but he should be well grounded in them.

Again, a large portion of the present work of the Freshman year might satisfactorily be required for entrance to the course, and the time thus saved could be devoted to work now occupying the Sophomore and even the Junior years, thus leaving later on time for higher studies. More time, too, could be gained for this purpose

in many schools by omitting unnecessary studies from the curricula, notably the foreign languages.

One of the most effective ways is to increase the number of working months in the year from eight or nine to eleven. This need not involve a hardship for either the students or the professors, because the summer months could be devoted to field work, which would afford rest for weary brains and would build up weak constitutions, while by employing more professors in the faculty the extent of each one's annual work could be reduced to any reasonable amount. The most effective method of all, however, is to increase the duration of the course to five years.

But all the additional time thus gained would not be sufficient to make each student a master of the theory and conversant with the practice in all branches of civil engineering, although the course that could be thus given would cover nearly twice as much ground as the average technical course at the present time. The strictly technical studies now occupy but little more than two years; consequently another year, when the student's capacity for work is so greatly increased by his previous study, would probably double the technical knowledge of the present graduate.

Courses such as just suggested are going to be given in the not very distant future; and they are in reality almost a necessity today. The rapid advances in engineering science are calling loudly for better prepared young men to fill for a short time subordinate positions, and then advance rapidly to places of trust and responsibility; and, as in all walks of life in this great country of ours, the supply is certain quickly to meet the demand.

The method that I propose for the advancement of engineering education in America to the highest possible plane, and to enable the studious, energetic, and ambitious graduates of all technical schools to continue their engineering studies in both theoretical and practical lines to any extent they may desire is as follows:

Let one of America's multi-millionaires found and endow most liberally a post-graduate school of civil engineering, in which would be employed as officers, professors, and lecturers men of the highest talent in the country, irrespective of what it may cost, and let the institution be established and equipped upon the broadest lines. There should be a comparatively small corps of permanent professors, but the principal instruction should be given by practicing engineers chosen from the best known and most competent in the profession. In order to secure them it might be necessary to reimburse them for their time even at maximum consultation rates. It would not do to

make a practice of paying much less, as each instructor should be placed upon his metal in order to insure the best possible results from his work. In some cases this might not be practicable, if the instructor felt that his work was something of a "charity job"; but if he were convinced that neither pecuniarily nor professionally would he be losing anything by teaching, he would be certain to put forth his best efforts and endeavor to teach each student as much as possible of the best he knows.

The function of the permanent professors would be to keep the various departments active at such times as the lecturers would be absent, and ensure that the students should always have some one to refer to concerning their studies and investigations. It should also be the business of the permanent professors to study current engineering literature, and to excerpt therefrom and deliver in the form of lectures everything likely to be of real value to the students, as well as to call their attention to the articles which each one ought to read. They should also teach the student the knack of reading current technical literature so as to obtain its gist with minimum effort and loss of time.

They should prepare a work discussing engineering literature that would include all technical books which are in accord with current practice, show their scope, and indicate their good and their bad points. This treatise should be re-written from time to time so as to keep it up to date.

The permanent professors should also be required to translate or assist in the translation of all engineering books in foreign languages, which, in the opinion of competent experts, would prove useful to American engineers or to the students of the institution.

The president or director of such a school should be the most broad-guage, profound, and progressive engineer in the entire country, and the governing body or trustees should look to him to see that the maintenance and development of the course of instruction are such as to accomplish to the utmost the great object of the school's existence.

Original investigation by both the professors and the students should be provided for and encouraged in every way, and the results should be published in an official paper of the institution. These investigations should be of an eminently practical nature and calculated to improve engineering practice or lead to valuable discoveries in technical science. A great testing laboratory, the most complete and perfect in the world, should be an adjunct of this institution, and its constant use should form a part of the curriculum.

Designing should be the characteristic feature of the course of instruction, and should be employed in every course where its use is practicable. Nothing will teach a man a subject involving engineering construction more thoroughly than the making of a complete and accurate design for some special case, unless perhaps it be the teaching of that subject to technical students. All designing should be done in the class room under the direct supervision of experts, and in the same detailed and thorough manner that is, or should be, characteristic of designing done in the offices of consulting engineers.

One prominent feature of the curriculum should be the study of both pure and applied mathematics, not only for the purpose of refreshing the memories of the students and supplementing previous faulty instruction, but also in order to carry this study farther than is customary in technical schools. The main object of the course, though, should be to teach the students to do original mathematical work, thus enabling them to solve difficult problems in the highest branches of engineering.

Another prominent feature of the course should be numerous visits by the professors and students, both together and separately, to works under construction, finished structures, and industries of all kinds; and special facilities for studying these should be arranged for in advance by the president or the governing board.

No special length of time should be set for the duration of the course, but each student within certain reasonable limits should be given the privilege of choosing his subjects and the time for taking them. It would be well to arrange to give those who do a certain amount of studying at the institution certificates to that effect, and to those who pass a satisfactory examination in one of a number of prescribed courses the degree of Doctor of Science or Doctor of Engineering, as the case may be; for the instruction given at such a school would certainly be as profound as that offered by any institution of learning in the world; and those fully profiting by it would most decidedly be worthy of a doctor's degree.

Let us now consider briefly some of the courses that I would advocate giving in such a post-graduate school of engineering. It is not my intention to try to make these suggestions at all complete but merely to outline some of the possibilities for extending engineering education.

A knowledge of political economy is of great value to the civil engineer in his relations with the government (national, state and municipal), with capitalists and corporations, and with manufacturers.

In acting for the government or in dealing with it, a thorough

knowledge of its nature and functions, the extent of its control over constructions, the relation between its fiscal and engineering departments, and its control over and obligations to the public, is essential to the successful engineer.

In dealing with common carriers and other quasi-public corporations, a thorough knowledge of their relation to the public, their responsibility to the government, and their organization and management, is of the greatest importance.

The engineer for a manufacturing concern should be thoroughly conversant with the operation of the law of supply and demand, with the relations between capital and labor, with the theories of competition, and with the organization of industries.

All these things and many others that come under the head of political economy should be taught in the proposed post-graduate school.

A general knowledge of law in its relations to contracts, organization of companies, rights of corporations, and many other important matters connected directly or indirectly with engineering work is essential to the highest professional success.

The fundamental principles of business should be taught to all engineering students, and they should be instructed carefully in respect to all such matters as stocks, bonds, and other securities, and the floating of same. Even such an elementary subject as the keeping of accounts should not be ignored.

Concerning the history of civil engineering I need say nothing here except that it should form a part of the curriculum of every technical school. Possibly many of you know that I am making a systematic and determined effort to induce the Society for the Promotion of Engineering Education to undertake the preparation of an exhaustive history of civil engineering in all its branches. Thus far nothing has occurred to make me despair of success in the accomplishment of this purpose.

But few technical men are fluent speakers, and as it is often the engineer's province to persuade capitalists into the undertaking of enterprises, or to argue in the defense of one's rights in competition or of those of one's clients in legal controversies, a knowledge of oratory and experience in debate must be of great service in one's professional career; consequently, the study and practice of these matters should be given due attention in the proposed post-graduate school.

The ability to dictate readily to a stenographer well expressed letters, descriptions, contracts, and specifications is enjoyed by very few engineers, and these few did not obtain their knowledge of this accomplishment at the technical school, but through a long continued

effort, much patience, and numerous discouragements. Every engineering student should be drilled in dictation until be becomes proficient.

The writing of first-class specifications and contracts is an art that cannot be acquired except through experience; nevertheless its acquisition can be hastened materially by a thorough drill at the technical school in the underlying principles of such writings, as well as in the practice of their composition.

In American schools of engineering the study of graphics is confined almost exclusively to the determination of stresses in framed structures; but in Europe it is carried much farther, entering into almost all kinds of computations. The graphical calculations of a highly educated German or Swiss engineer are beautiful to contemplate; and although it may not be advisable to utilize graphics in practice to the extent that these foreign engineers are inclined to, nevertheless, in my opinion, American technical schools have much to learn in this particular from those of Continental Europe. On this account it would be well to include in the proposed curriculum an elaborate course in higher graphics.

The subject of economics is one that is intimately related to every branch of civil engineering, and its importance is such that not only, as previously stated, should it receive due attention in the study of all such branches, but also it is deserving of a special course, in which its relations to all important professional and business affairs are expounded.

Few American engineers pay much attention to secondary stresses in framed structures, but European engineers are trained on their theory; and while it is true that the best way to treat secondary stresses is to avoid them in one's design, still a comprehensive knowledge of their cause and magnitude would enable one to do so to far better advantage; hence a course in their theory should be given in our post-graduate school.

As far as I know, the science of railroading is not taught in any technical school, the elementary principles and practice of surveying and construction constituting the extent of the course in that subject. The science of railroading pertains to more abstruse subjects, such as the adjustment of grades and curves to traffic; the laying out of terminal yards for economical handling of cars; the reconstruction of cheap roads so as, with minimum interruption of traffic, to change them into first-class trunk lines; the economic maintenance of track and rolling stock; the relations that motive power, car equipment, rails, ties, ballast, speed, and volume of traffic bear to each other; and how changes in any one of these features affect the rest. A thorough

course in all such details of railroading would be of great value to the student and of the utmost importance to the railroad system of the country.

The true science of bridge design does not receive much attention in technical schools, or at least it is only its elementary features that are treated. The reason for this is not lack of proper books, but want of time. In our post-graduate school there should be given a course in bridges far surpassing in extent, thoroughness, and excellence any course on the subject yet given or even contemplated. The new types of steel-and-concrete bridges should not only be covered in the course; but also the permanent professors both by experimentation and mathematical investigations should establish a proper theory for the designing of such structures. Substructure and foundations should be treated much more elaborately than is customary in other technical schools.

The study of geodesy in both theory and practice, with the necessarily closely associated theory of least squares, should be given proper attention.

A much more elaborate course in instrumental work and measurements of precision than is usual should form a part of this curriculum; and all the latest and most complicated types of surveying instruments should be described in the class room and used in the field. A student's knowledge of an instrument should not be considered complete until he has learned to take it apart, clean it, put it together, and bring it into perfect adjustment.

Measurements of precision, equal in accuracy to those performed by the leading engineers on important bridge work, should be made by the students under the direct supervision of expert instructors.

An elementary but complete course in architecture, especially as it relates to engineering constructions, should form a part of the curriculum; and special attention should be paid to æsthetics in designing.

A sound, practical working course in geology, mineralogy, and allied subjects should not be omitted.

A special course should be given on tunneling, and it should include the designing of tunnels of all kinds to meet all possible conditions.

There should be also a thorough course on the designing and construction of dams of every description.

In the course on the metallurgy of iron and steel the student should obtain a thorough acquaintance with the mechanical processes and the chemistry of their manufacture according to the latest practice; and a full description of all previous and abandoned methods

should be given, as a knowledge of what has been done in the past often saves a great amount of labor when an endeavor is made to improve upon present methods; and long disused plans are frequently re-invented at great expense.

A knowledge of the action of iron and steel under the ordinary working conditions is essential to the proper use of these metals in designing. A general idea thereof obtained from a few tests and lectures, such as is commonly gained by the engineering student, serves principally to befog the mind of the young engineer, and leaves him wholly unprepared to handle problems involving rapid vibration or heavy shock. On this account the testing of these metals in various forms and under differing conditions should be included in the course of instruction.

The designing and construction of harbors and canals of all kinds and the improvements of rivers under all possible conditions should be treated much more elaborately than is customary in technical schools; and hydraulic experiments with the latest and most improved types of current meters should be made by each student in the class.

The important subject of water supply should be taught in full detail, and experiments on the flow of water in pipes and a study of bacteriology should constitute portions of the course.

An exhaustive study of sanitary engineering and all its important features should be included as a part of the curriculum, and sewage disposal should be studied thoroughly by both professors and students for the purpose of effecting much needed improvements in that branch of engineering science.

Power transmission by the latest and most economical methods should also be taught.

Highway engineering should not be neglected, and the effect of good roads upon the development of a country or a district should be investigated.

No civil engineering curriculum is complete without elementary but thorough courses in mechanical engineering and electrical engineering; consequently there should be special departments for them in our post-graduate school; and the professors in these branches should endeavor to evolve a complete set of scientific principles for designing the details of machinery, corresponding somewhat in style and extent to the principles that have been established for the designing of steel bridges.

The advantages to be obtained by attendance at such a post-graduate school as the one advocated are almost beyond expression! A degree from such a school would always insure rapid success for its

recipient. Possibly for two or three years after taking it a young engineer would have less earning capacity than his classmates of equal ability from the lower technical school, who had gone directly into actual practice. However, in five years he certainly would have surpassed them, and in less than ten years he would be a recognized authority, while a majority of the others would be forming the rank and file of the profession with none of them approaching at all closely in reputation the more highly educated engineer.

But if the advantages of the proposed school to the individual are so great, how much greater would be its advantages to the engineering profession and to the entire nation! After a few years of its existence there would be scattered throughout the country a number of engineers more highly trained in the arts and sciences than any technical men who have ever lived; and it certainly would not take long to make apparent the impress of their individuality and knowledge upon the development of civil engineering in all its branches, with a resulting betterment to all kinds of constructions and the evolution of many new and important types.

When one considers that the true progress of the entire civilized world is due almost entirely to the work of its engineers, the importance of providing the engineering profession with the highest possible education in both theoretical and practical lines cannot be exaggerated.

What greater or more worthy use for his accumulated wealth could an American multi-millionaire conceive than the endowment and establishment of a post-graduate school of civil engineering such as I have tonight attempted to describe!

Should this address of mine by reaching the eye of one of those multi-millionaires be the means of inducing him to endow such a school, I should consider its preparation to be the greatest work of my entire professional career!

THE DEVELOPMENT OF ENGINEERING AS A PROFESSION IN THE UNITED STATES.

By

Dr. Charles H. Snow.

This address, issued since the appearance of our first edition, has been incorporated in the second edition for three reasons:

First. It is quite different in style from nearly all the other addresses, being of an historical nature.

Second. It treats of a most important question, viz., specialization in technical education.

Third. It comes from the pen of one of America's leading technical educators, Dr. Charles H. Snow, Dean of the School of Applied Science of the University of New York.

Specialization in engineering education is certainly a mistake; because an engineer to be thoroughly educated needs, primarily, a broad cultural course, secondarily, a thorough training in mathematics and the natural sciences, and, thirdly, a general education in all lines of engineering practice. To this extent, and to this only, are the Editors willing to concede on the subject of specialization in engineering education—the students in each of the four principal divisions of engineering, viz., civil, mechanical, mining, and electrical, should go somewhat more deeply into the studies that bear most directly on the work of their own division, but at the same time they should be thoroughly founded on the fundamentals in all three of the other divisions. It is true that this cannot be done in a four years' course; but it is now pretty generally conceded by the most advanced technical instructors that a thorough course in no line of engineering can be given in that length of time.

Dean Snow touches incidentally upon another matter of great importance in the training of young engineers at college, viz., the all-too-prevalent tendency that exists among them to slight certain studies which they deem of minor importance or even as non-essential. How manifestly valueless is a student's judgment of what is and what is not essential to professional success! And yet how positive young men are in holding such opinions! It is characteristic of the young American to claim that he knows far more than his father, because the latter is old fashioned and has not kept up with the advancement of modern

times; and the young college student carries this habit of thought to still greater lengths by claiming positively to know better about matters educational than do those elderly men who have devoted their lives to trying to solve the very questions that this tyro has settled with the greatest ease and assurance.

If each freshman student, as he begins his technical course, were to make up his mind that the curriculum of his school has, by long continued development, been laid out so as to do him the greatest possible good in the time allotted, and would determine to neglect no studies whatsoever, he would save himself from making some serious mistakes that are likely to be the cause of deep regret in after life.

Charles Henry Snow was born in New York City, March 24, 1863, and was graduated from Chapin Collegiate School in 1880, standing first in his class. Next he studied in New York University, taking there in 1886 the degree of Civil Engineer. In 1894 the University of Pittsburg conferred upon him the honorary degree of Master of Science, and in 1898 he received from the same institution the honorary degree of Doctor of Science.

Since his graduation in 1886 he has been actively engaged in surveys, explorations, reports, and other work as civil and mining engineer; and in 1891 he was appointed acting professor of Civil Engineering in New York University, becoming Dean of the School of Applied Science in that institution in 1897.

He is a member of the Phi Beta Kappa Society, the General Society of Mayflower Descendants, the American Society of Civil Engineers, and the American Institute of Mining Engineers.

He is the author of numerous valuable papers and books on the subject of wood.

Editors.

THE DEVELOPMENT OF ENGINEERING AS A PROFESSION IN THE UNITED STATES.

By

Dr. Charles H. Snow.

The term "Civil Engineer" means "Civilian Engineer," and is thus distinguished from "Military Engineer." Engineers were once almost wholly in government employ. We can imagine this of the builders of the pyramids, and we know that it was so in later times when engineers accompanied and sometimes commanded large armies, or, in times of peace, constructed fortifications or military highways. Other enterprises, such as the occasional construction of aqueducts and bridges, in which art was to be associated with utility, were allotted to the architect. Civil Engineering was unknown.

The latter period of engineering history began with the comparative cessation of warfare that followed the imprisonment of Napoleon, and with the introduction of the use of steam. In contrast with the former period, it is characterized by the need for and the encouragement extended to private, that is, *civilian* undertakings.

It is necessary to distinguish between the situation as it was in Europe and as it was in this country at the beginning of the last century. In Europe, the accumulated works of centuries were, for the most part, simply to be subjected to further change. In North America, at a time when steam and other practical applications of science became available for the first time, vast territories were to be altered from a state of almost absolute wilderness, to meet the needs of a high and comparatively peaceful civilization. The *European* engineer had then to do with problems of improvement or development in localities where kings and armies were well nigh supreme; the *American* engineer had to do with problems of creation in a land where armies were secondary and where the government was by the people.

The ranks of engineers in this early century were filled by graduates of military schools, or by office trained men, or by those whom circumstance had drawn into the field of constructive work and whose ability kept them there. Such men were fortunate, in that they lived when many practices were in their infancy. They did not have to attend scientific schools; such schools did not exist. Progress became rapid

and the facts to be classified so numerous that most engineers were obliged to give constant attention to the lines of work to which they had been drawn, and, as a result, many became specialists from the start. It was doubtless this tendency toward early specialization that led colleges to organize *many* kinds of engineering courses, each one teaching students very much as if for a separate profession.

The degree of Civil Engineer was given for the first time, at least in any English-speaking country, at Rensselaer Polytechnic Institute in 1835, and, although civil engineering may have been introduced elsewhere as a study, up to about the year 1850 there were but two colleges in the United States where students could qualify as engineers, namely, West Point and Rensselaer. At that comparatively late date, the calls for engineers were so few that Rensselaer is credited with a total of but 232 Alumni. At the same date, some 1500 men had been prepared at West Point, of whom 182 only had resigned to practice as civil engineers.

The late Civil War marked the time of the first genuine activity in civil engineering work. The opening of the far West was associated with so great a demand for men that practically all of the leading American colleges were led at least to consider the establishment of engineering courses. *Our* records show that engineering was first substituted for other subjects in New York University in 1855; but the engineering degree was not given here until 1862. From this time on, many kinds of engineering work were inaugurated throughout the country; and what may be called the eras of canal engineering, railway engineering, highway engineering, mine engineering, electrical engineering, and sanitary engineering have been or are being passed through. In each period, the fulfillment of some need reached an apparent maximum, and processes became more or less simplified. All institutions of learning, however, apparently did not distinguish between the transient and the permanent—the foundation and the superstructure—during these formative times, since four year courses leading to degrees in railroad, topographical, canal, and other kinds of engineering were organized by a few of them and then abandoned.

Specialization exists in engineering, but it belongs to the practitioner. Real specialists are not made by differences in college courses, but by time, circumstance, and adaptability. It is a significant fact that it is generally impossible to tell the kind of course or school from which the engineer of eight or ten years' experience was graduated. Practicing engineers have tended to segregate around four principal centers only, as is shown by the existence of the four great national engineering societies, and on this basis, engineering work is divided into

Civil Engineering, Mechanical Engineering, Mining (including Chemical and Geological) Engineering, and Electrical Engineering. These divisions include all others and are the only ones in which the average beginner need feel interested. It should be noted that even these divisions refer strictly to *work* rather than to men, since an engineer in charge of any operation must enter the limits of many fields in its prosecution.

The tendency to prepare undergraduate specialists, fortunately, is diminishing, and will probably diminish yet more with the passage of time. You, as undergraduates, will do well to devote yourselves to the mastery of principles that underlie *all* of the branches of your profession. This is provided for in the courses given you. These subjects may not interest you equally, but you will be benefited by everything that is presented to you.

There are subjects that do not appear to be professional subjects, but which are so in the highest sense. For example, it may surprise some of you to learn that the success of the engineer is influenced practically as much by a knowledge of English as by a knowledge of Mathematics. Clients are not attracted by engineers who cannot write, spell, or express themselves correctly. *All* of the subjects that you will study are engineering subjects; and in this connection, let me suggest that for the present you attend to the duty of each day and that you do what there is to do as well as you can, regardless of whatever interest or preference you may feel.

Further, remember that engineering is in no sense narrowly scientific; that the influence of personality is as marked as in other callings. A college course is only a tool; a man must be behind it. The weakest arm is the better for the weapon, yet alertness, common sense, steady purpose, balance, integrity, far-sightedness, and the ability to get results, are also needed for what the world calls true success. Let me urge you as Freshmen, and you, the members of other classes, to advance your interests by trying to cultivate these qualities.

THE STORY OF A LIGHTHOUSE.

By

Dr. A. J. Du Bois.

Greatly to the Editors' regret, the manuscript of this paper reached them just too late for insertion in the first edition. However, they welcome the opportunity to incorporate it in the second edition as an example to young engineers of the heights to which technical literature may aspire; for this oration may well and truthfully be termed a "prose poem." It stands out boldly as a refutation of the claim so often made that the writings of engineers are of necessity dry, technical, and uninteresting to laymen. The stirring words and noble thoughts with which the address abounds must appeal forcibly to the heart of every technical reader and stir him to the depths; for it makes manifest in glowing terms the loftiness and grandeur of the "Profession of Engineer." Its diction is a model of elegance and style, and the paper should long serve the engineering profession as an example of the possibilities of attainment in technical writing.

Dr. Du Bois, who is well known, wherever the English language is spoken, as a technical author and teacher of the highest standing, has for many years occupied the chair of Civil Engineering at the Sheffield Scientific School of Yale University. His numerous works on bridges, graphics, and other engineering subjects rank among the best technical treatises.

Augustus Jay Du Bois was born at Newton Falls, Ohio, April 25, 1849, and studied at the Sheffield Scientific School, taking the degree of Ph. B. in 1869, that of C. E. in 1870, and that of Ph. D. in 1873. He next studied mechanics for two years at the Freiberg Mining Academy in Saxony.

From 1875 to 1877 he was professor of Civil and Mechanical Engineering at Lehigh University, after which he occupied for seven years the chair of Mechanical Engineering at Sheffield, and since 1884 he has been Professor of Civil Engineering at the latter institution.

Dr. Du Bois' thorough knowledge of the German language has enabled him to translate and publish in America several important technical German books which have been of great service to the engineering profession in this country.

Editors.

THE STORY OF A LIGHTHOUSE.

By

Dr. A. J. Du Bois.

"Arma virumque cano!"
"Arms and the man I sing!"

Such was the introduction, many long years ago, of a great poet to his greatest work. And he did well to select as the subject for his muse that one theme which never can grow old so long as sun and moon endure—*Arms and the* MAN.

Many years have passed since the poet wrote these words, and the earth has seen vast changes since; but today, history and poetry, art and literature—Ay! and even science too—throb with the interest attaching to that same old theme, the changes upon which have been so often rung, which has never grown worn through all the ages, which lives in every romantic tale and glows in every fossil, whose keynote the ancient poet struck with so sure a hand so many years ago, of DEEDS *and men.*

Deeds and MEN! Human achievement and human character! These, in endless variation and iteration are the themes of which we never tire to read and think and tell—the perennial fountains whence we draw inspiration and drink fresh courage in our own humbler doubts and difficulties and dangers. History and poetry, art and literature—even religion itself—what is their interest to us! except they speak to us of man—man in his relations to his fellow and to himself—what he has done or may do; what he has thought and suffered and endured; what he has been or may yet be. Talk as we may, and sometimes do, of the "love of knowledge for its own sake," the most abstract science offers to its most enthusiastic votary no other inducement, no higher reward, than the recognition and appreciation of those elements of human interest and human sympathy, which irradiate its dryest details and make its dry bones live again. Not only is the "proper study of mankind, man," but it is indeed his only study. Man in his trials and dangers and failures and successes; in his weakness and his strength; in his temptations and his triumphs—this is the study which appeals to every human heart; which illumines and vivifies with light and

warmth every pursuit in life, and adds to the dryest science the charm of human interest and the incentive of human example.

As the stars in heaven derive an added interest from the fact that as they once shone and looked to the countless ages past, even so do they shine and look down upon us now; so do the ordinary prosaic pursuits and avocations of today—our daily toils, dangers, and trials; our failures and our successes; even our own fears and loves and hates—possess for us a special interest from the fact that from the beginning man's life has been but a tangled tissue of just such experiences as those which we encounter now. The scene and stage accessories may shift and change, but there is nothing new in experience under the sun. "Our feet tread ways our fathers trod," and in this community of sympathy, no story of human achievement, of human life, or human death but is full of interest, of encouragement, or of warning to ourselves.

Upon this well worn theme of deeds and men we play our humble variation tonight. What though we go out of the usual beaten track to gather our examples! Deeds are still deeds, and men are still men, whether they do manly deeds in oft told tales of crusade and chivalry, or sturdy yeoman service in the humbler sphere of daily life and duty. The interest may be none the less; the value may be quite as great; the heroism all the greater. "That is best which lieth nearest," saith the poet, yet our poets must seek far off fields from which to cull the flowers of romance—the farther and less known the better—and, so well have they done their work in their chosen fields, there scarcely seems a flower left to pick or a deed to tell. They climb the mountains and explore the very stars in their search for the new and striking, while all the while, in the peaceful valleys and along the margins of the quiet streams of daily life, in our very midst, there is many a lovely flower to reward their search, many a noble example or heroic deed —none the less noble or heroic in that it hides itself modestly beneath a stone or clothes itself in the workman's frock.

Here then, is a field for the poet, the historian, and the painter, which has been all too little regarded—an almost virgin soil, which will well repay cultivation and which may yet furnish the epics of the future.

The story of man's struggles—not with beast or fellow man, but with the mighty relentless powers of Nature—of his conquests, not in love or war, but of reason and intelligence—these are high and worthy themes which have waited long and still wait to find their chosen minstrel. Is there no inspiration here! Our greatest benefactors are not those of song and story. The tombs of our greatest warriors still wait for their inscriptions; and those great battle fields which have decided

the fates of nations and of civilizations have not been won by sword or spear. Brains count for more than muscle, and man's noblest victories are bloodless ones.

Born into the world powerless, defenceless, the most helpless animal that sees the light, man has steadily and gradually subdued the forces of nature to his will. Skillfully and cunningly he pits them one against the other and makes them obedient to his bidding. He defies the winds and rules the waves and leads the lightning in chains of its own forging. His entire history but serves to illustrate the supremacy of mind over matter. It is in the exercise of this, his proudest birthright, that man is best exhibited, and offers to the poet and the historian the most worthy themes for study and contemplation. Not man in his weakness, the sport of circumstances and the slave of passion, but man in his strength—the ruler of Nature in the image of his God.

Men and deeds then—but in a higher and more worthy sense than the ancient poet ever dreamed—shall constitute my theme tonight. I have to tell of no little Julius or wise and pious Eneas or aged Anchises—of sack and pillage and cunning manœuvre—no mailed knights and floating plumes and martial music and soldierly deeds of blood and violence! No swords Excalibur—no widow's tears nor ophans' curses, no savage and debasing passion, no rapine, murder, and sudden death! No romantic nor questionable escapades form the subject of my story. My plain, unvarnished tale needs no such spice as these. But in all true elements of human interest; in bold unflinching courage; in energy and perseverance and noble indifference to danger when in the path of duty; in manly self-reliance and readiness of resource; in battle not with men nor beasts, but with the winds and waves; in resolute defiance, not of the malevolence of man or demon, but of the fierce, unrelenting, remorseless powers of Nature—hard knocks too, Ay! and even heroic death—of these elements and such as these we have enough; and these are elements which in every form and age and fashion, whether in romantic verse or the plain garb of humbler prose, must appeal to every human heart and awaken responsive sympathy in every human breast.

To a simple story culled from this too long neglected field, let me then ask your attention tonight. I may not tell it as it should be told, nor make my words entirely good, yet the deeds I have to tell cannot but speak for themselves in tones which need no words of mine to point their emphasis. The men I sing have worked hard and well for small reward, for you and me, and dying, have left us in their characters a far better legacy even than their manly deeds. Of these let me tell, as best I may, and your appreciation and sympathy must do the rest.

If, now and then, I make some brief excursion, you will, I trust, extend to me the "benefit of clergy," and at least will patiently allow me to ram home my dryest statements, with a more or less substantial wad of "personal application."

The story I have to tell possesses, indeed, an interest almost dramatic in its character—a drama in which the actors are strong, skilled, determined men on the one side, and the tremendous forces of Nature upon the other.

About fourteen miles S. S. W. of Plymouth harbor, lies a reef which needs no Lorelei to add to its fatal efficiency. Lying low down in the sea, it slants its glistening spine to the rolling waves and fairly lifts them high into the air, dark green and capped with foam, solid, massive, and terrible; while in and around its treacherous neighborhood the water boils and eddies and surges to and fro, when current meets countercurrent, as in a mighty caldron. However calm it may be elsewhere, here there are constant turmoil and ceaseless roar; and in these raging seas hundreds of vessels have been dashed to pieces almost within sight of land and safety.

Such is the reef called the *"Eddystone"*; and while seeking to avoid its fatal neighborhood, many a luckless mariner has gone from Scylla to Charybdis and met the very fate he feared among the Islands of Jersey, Guernsey, and Alderney, and upon the coast of France. In every storm that terrible reef made good its fatal reputation, and strewed the shores of Plymouth Sound with wrecks and corpses. Like the fabled monster of old, it crouched just beyond the city walls, and every year it levied upon the panic stricken inhabitants its fearful tax of blood and treasure.

Then, as in the fable, *Perseus* came. Our modern Perseus had neither polished shield, nor magic sword, nor winged sandals. No gifts from the gods were his, save his clever hands, resolute will, honest heart, and ready brain. No youthful hero with ambrosial curls; but a rather bald, somewhat portly, plain, middle-aged, well-to-do country gentleman and mercer, or merchant tailor, of Littlebury, County of Essex—very unassuming, and, for the sake of the ladies, I grieve to have to say it—probably not even "good looking!" Rather prosaic stuff for a hero this! But this modern hero stood upon Plymouth Hoe one day, perhaps upon the very spot where Drake once stood, when the Spanish Armada was first descried making for the English Coast, and looked out to sea like Drake, but with a very different object. In the rain and the sleet and the wind, his cocked hat slouched over his eyes, the rather voluminous, not to say "baggy" clothing of those days

flapping in the gale, with one eye shut and a glass at the other and his legs astraddle, looking anything but the conventional hero of poet and drama—behold the modern Perseus! Smile at the description if you will, but such in all probability was the entrance of a veritable hero and genius upon a drama which was to close only with his life, and in which his manly part was to hand down his name to admiring generations. No carpet knight, this! No nursery hero! No soft-handed, softer-headed young ladies' *beau ideal!* No poetic and romantic figure, with flush of youth and bravery of trappings, and celestial backing to see him through without a scratch! But a resolute, determined man, alone in the wind and the storm, terribly in earnest, and animated by as pure a spirit of self-sacrifice, as high an ambition and as noble a desire for the good of his fellow creatures, as any of the more brilliant creations of minstrel or poet! His story possesses, moreover, an interest which theirs too often lacks—*it's true!* Beneath that plain exterior there lay a stout heart and as stout a will; and as he calmly leveled his glass and squinted out to sea, he was revolving, like Ulysses of old, "great things within his mind."

He looked out toward this insatiate monster, which had robbed him of two fine ships, and saw it dashing the waves in its savage glee high into the air from its dripping back, and heard that terrible roar which had been the death knell to so many gallant souls; and in the midst of the din and uproar of the elements, which seemed to laugh and mock at human weakness, he stood and looked over the dismal fourteen miles of rainy sea, and quietly resolved to devote what remained to him of fortune and of strength, in the unequal battle, and, if it might be, to demolish the tyranny of this "rock of destiny." Was ever greater conceit! Alone, unfriended, the little man in the cocked hat had entered the lists against the most destructive power known to man. No man had ever dared to tread that way before. He knew no similar examples from which to draw encouragement or warning. The monster shrieked defiance and derision and foamed with rage and scorn, but Winstanley of Littlebury calmly and quietly went to work. The mouse versus the lion; the spider against the bear; the man against the rock! He asked, and got, no aid from a churlish government, though engaged in the most unequal battle ever waged by man for the common weal. Still he worked on. Men laughed and jeered at the enthusiast, the fanatic, the man who dared to fight the Almighty. Still he worked on. He heeded their mockery as little as that of the winds and waves, and quietly went his way. And now began the battle of the rock and the man, of mind and matter, of brute force and brains; and into the Her-

culean contest Winstanley threw all his property, his dauntless energy, and, ere the close, his life itself.

Whenever we find a great man taking advantage of a great opportunity and rising equal to a great emergency, we find invariably that, consciously or unconsciously, generally the latter, he has been prepared for that emergency and that opportunity—prepared by training, by character (which is the outcome of training), by experience, by study and special knowledge: and these all contribute to his success. There is no such thing as *luck* in such matters. "Fortunate combination of circumstances" there may be, but if the man is not ready to profit by the combination, the combination will never come for him. There may be a tide in the affairs of men, which taken at the flood leads on to fortune, but if the man can't swim, the ebb will surely leave him high and dry upon the shore, still fearing to take the plunge and railing at the "luck" of those who have dared to. Opportunities! why they lie all around us, to-day and every day, waiting for us, inviting us, imploring us to seize and to utilize them. And when now and then the man does come, who yokes them to his will and rides upon them to success, what a host are always ready to cry out upon his "luck," as though, forsooth, he has stolen their thunder!

What special qualifications had Winstanley for the unequal strife which now commenced? The question is pertinent, for without such qualifications his great resolve would have been, what it then seemed to so many to be, but ignorant conceit, and his great opportunity have only led to as signal a failure.

Winstanley was what we call now-a-days a "born mechanic." Besides his property, which was considerable for those days, and the gifts of the gods of brain and heart and hands, he had a passion for mechanics—a hobby which his prosaic employment could not cripple, and which he rode incessantly to his own satisfaction and to the great discomfiture of his friends. Smeaton tells us that "he had at his house at Littlebury a set of contrivances, such as the following: Being taken into one particular room in his house and there observing an old slipper carelessly lying in the middle of the floor, if, as was natural, you gave it a kick, up started a ghost before you. If you sat down in a certain arbor by the side of a canal, you were forthwith sent adrift to the middle of the stream."

In these and like curious inventions Winstanley had passed his leisure, and useless as they appear, they sufficiently attest his genius and his tastes, and undoubtedly they developed a skill and ingenuity of contrivance and a readiness of resource, which were now to be

applied to worthy objects and to stand him in good stead in the hour of need. So true is it, that our very recreations may tend to nourish or enfeeble our powers, give active aid in the execution of our duties themselves, and all unconsciously build themselves into the very fabric and tissue of our character. All unconsciously, in his hours of leisure, Winstanley had been preparing himself for the great opportunity and work of his life. Opportunity at last had found the man, and it found the man ready for the opportunity. His project, in the light of his experience, was no fool-hardy, quixotic scheme. It was well considered. He had seen his foe and gauged his strength. He had measured himself against the rock, had boldly entered the lists, *and he meant to win!*

Four years the contest lasted. How shall I do justice to that terrible fight! How tell of the sufferings and privations, of the fortitude and endurance, of cold and hunger and danger and death, of long, sickening delays and sinkings of heart, of alternate hope and despair, as with varying fortune—jeered at by his very workmen—the battle progressed! Heedless of mockery, foremost in danger, undismayed by failure—here are a hero and a battle worth the poet's pen. Now the man would gain a slight advantage, and now the remorseless winds and waves would tear down in one hour, with malicious glee and frenzied shrieks, the patient toil of months. Often, caged on that lonely rock, shut off from all human aid, dispirited by hunger and cold, the dauntless man looked death full in the face, and yet, in his own brave words, "trusting in God's assistance for a blessing on this undertaking, being for a general good, and receiving most inexpressible deliverances, I proceeded."

The result of that whole first year—twelve dreary months of perilous labor, uncheered by sympathy and marked by disaster—was simply twelve holes bored in the solid rock. Twelve small holes of three inches diameter, and that was all! That was all, but that was enough. The monster was then vulnerable. His hide was pierced. A foot-hold on that terrible rock was at last secured. It is the first step which costs. The rock at last had met its master.

In these days of universal travel, when all good Americans go to Paris before they die—wherever they may go after—probably eight out of every dozen, within reach of my voice to-night, owe their lives, or the lives of those near and dear to them, to those twelve small holes, and the man whose determined courage sank them. Thanks to them and him, wrecks no longer line the shores of Plymouth Sound; the British Channel is now lit up along its whole extent, and is as safe in

the darkest night as in the brightest sunshine; homeward bound ships from far off ports no longer avoid the dreaded rock, but eagerly run for its light as the harbinger of safety; and many a heart has leaped with gladness at the cry of *"the Eddystone in sight."*

The work now went bravely forward. Encouragement and tardy sympathy began to come. The man was no longer a lunatic. There were even not wanting those who knew all along, "it was easy enough." They always "thought so." They always "said so!" They were even ready with advice and assistance and suggestions. But the man who had got along thus far without their assistance could easily dispense with their valuable advice. Thanks to those twelve small holes, the next year saw a pillar, 12 feet high and 14 feet in diameter, tied down and anchored to the solid rock. With this puny building the elements made their sport. The wind whistled round it in derision, and the waves dashed over it, literally submerging it at every swell. But the little pillar stood fast and gave not way, and every day it grew stronger and higher, and the patient, much-enduring man may have smiled in anticipation of final triumph, but he worked away indefatigable as ever. Let him tell his story in his own modest words.

"The third year the aforesaid pillar was made good at the foundation from the rock to 16 feet diameter, and all the work was raised. Being all finished, we ventured to lodge there, soon after midsummer, for the greater dispatch of the work." *We ventured to lodge there!* I like to think of the unconscious pluck and daring in the simple words. Not three years past and the man is actually making his abode upon the rock! No wonder the bold challenge was accepted, and the winds and waves awoke to the fact that the despised intruder was getting over-bold and needed a lesson! "The very first night," the report goes on, "the weather came bad, and so continued that it was eleven days before any boats could come near us again, and not being acquainted with the height of the seas' rising, we were almost all the time drowned with wet, and our provisions in as bad a condition, though we worked day and night as much as possible to make shelter for ourselves. In this storm we lost some of our provisions, though we did what we could to save them, but the boat returning, we all left the house, to be refreshed on shore, and as soon as the weather did permit, we returned again and finished all, and put up the light on the 14th of November, 1698, which being so late in the year, it was three days before Christmas before we had relief to get on shore again, and were almost at the last extremity for want of provisions. But by good Providence, then two boats came with provisions, and so ended this year's work."

It was a harbinger of good omen for the eighteenth century, that it opened with such a work as this; and the people, not alone of

Plymouth town but of all England, might well mingle thanksgiving with their rejoicings over Winstanley's Christmas gift. Seldom does a city or nation receive, free of all expense, such a royal gift—a gift in which ultimately all the world were to be sharers. For Winstanley, alone, unaided and in the teeth of ridicule and skepticism and danger, had shown the way and demonstrated the possibility of that which before was thought impracticable. Once proved that a house could be built and live at sea, and in such a sea, men and means were easily to be found to repeat the experiment and cause lights to burn in every dangerous spot and along every dreaded coast.

"In the fourth year," the report goes on, "the work was raised to 120 feet, and yet the sea in storms, flies in appearance one hundred feet above the vane, and at times doth cover half the side of the house and lantern as if it were under water."

Let those laugh who win! It was now Winstanley's turn to make merry, and he did so right heartily in his own characteristic and eccentric fashion. "Not build a tower upon that rock! Why, I'll build ye, an ye will, a Chinese pagoda!" And he added, "gables and turrets and balconies," and pointed his mockery by representing himself as fishing out of the kitchen window!

Thus the man had conquered the rock in a battle as desperate as any in the bloody annals of war. Upon the highest point of its jagged back he placed a beacon; and many a gallant ship and brave sailor were saved by it during the next three years, and had cause to bless its warning light and the man who set it there in the midst of the wind and the waves. If Winstanley, with all the power and wealth of a great nation to back him, had destroyed in an unjust war as many lives and as much property as by his own unaided and heroic efforts he had saved; or even had he killed off a few, wretched, half-naked savages, history would have lauded his name as that of a great captain, and titles and medals would have showered upon him in profusion. But a simple mechanic, who leaves behind him only a rich legacy of happiness and prosperity instead of hatred, what has history to do with such?—even though the influence of his life and death and works is felt today throughout the world!

History! Why, if the fanciful prophecy of a writer in the Atlantic of a year or so ago should ever come true, when the coming New Zealander of A. D. 3758 shall uncover the ruins of our present boasted civilization, and seek, from the few remaining relics of the past which the all-devouring tooth of time may have spared, to reconstruct anew the life and times of today—it will not be from the rotting volumes which now line the shelves of our libraries that he will glean the knowl-

edge that he seeks. Such scanty remnants as may then remain of our industries and our manufactures and our arts will be all that will be left to speak to him of the power and the genius and the character of a once mighty people—of the age of the cotton gin and the printing press and the steam engine and the telegraph and the photograph and the telephone and the electric light. And should he, perchance, turn over the mouldy pages of our "histories," so-called, to learn the names and read the lives of those giants of our race, whom we must have *so* delighted to honor—those great benefactors, who bore upon their mighty shoulders our entire civilization like a feather, and whose works alone remain to rescue us from oblivion and challenge the respect of posterity—he will search amongst the records of bloody battles and party strife and local politics and puerile Congressional debates and the wranglings of Presidential elections—and he will turn and seek and search, in vain. That which gives to us today, and will give to us then, if that time ever comes, our real character and genius and *national flavor*—our true place in the history of the world's progress in thought and achievement—ignored and unnoticed, while vain pretension and martial achievement and crafty diplomacy fill the volumes which claim to record our national existence!

Well! You all know the end of my story. How, in the fearful storm of November 26, 1703, one of the most terrific that ever raged on that coast before or since, the elements combined in one last and final struggle against the adventurous man who had dared to oppose their mighty power, and swept both house and builder into the pitiless sea. When morning broke after that terrible storm, the dead lined the shores of Plymouth Sound, and off in the distance, lay, growling savagely, that angry monster, dark, sullen, terrible, still unconquered, and only the more ravenous for blood and treasure by reason of its long enforced fast. And the one man in all England who had ever dared to give it battle, lay tossing in the breakers, the sport of the merciless elements he had so long defied, his stout heart stilled forever, his idle hands, that were so strong in good works, tossing feebly and aimlessly to and fro, and his dead, white face looking up to the gloomy, wintry sky. Of the light he had with so much toil and patient labor erected, not a stick nor a stone remained!

But yet one thing did remain—those twelve small holes in the monster's back, holding up to all the world their lesson of patient endeavor, and proclaiming to every passing vessel—WINSTANLEY—HIS MARK! And another thing remained—the memory of the man who made them and his great example. The rock had not conquered the man, for the man still lived. We may even fancy that in that terrible

night which was his last on earth, as each sea burst over the doomed house and shook it to its foundations, he heard in the roar of the storm and the hoarse shrieking of the wind the cheers of dead mariners and the plaudits of the living; and as the wreck came crashing down, he may even have smiled in his brave, undaunted heart at the thought that, let come what may, he had yet conquered, and with that smile in his heart and on his face, gone calmly to his fitting death and grave.

Winstanley showed the way. He demonstrated that the thing could be done. As Smeaton generously observes, "It was no small degree of heroic merit in Winstanley to undertake a piece of work which had before been deemed impracticable, and by the success which attended his endeavors, to show mankind that the erection of such a building was not in itself a thing of that kind." Winstanley's work and example were not lost. Such lives and examples never are. But at first, no one stirred to follow, until one day the monster opened his mouth again, and this time it was the *Winchelsea,* a richly laden, homeward bound vessel, lost with every soul on board. Then at last Government awoke to the necessity of a light house on that dangerous reef, and John Rudyerd was the man they called to the work—singularly enough, another London mercer.

Rudyerd was the son of a Cornish laborer of bad habits and worse character, and the rest of the family seem to have been but little better. "A worthless set of ragged beggars" Smiles calls them, "John being the one sound chick in all the brood." Certainly, opportunity does not seem to have done much for him, yet he must have become well-known for mechanical ability, or he would never have been selected for such a work. The philosophic Smeaton, who never loses a chance to moralize, remarks concerning him as follows: "This shows that though education and example may do much, yet there is something in natural disposition not totally to be eradicated by education. Had Mr. Rudyerd's parents been of the most amiable character and if one of their children had turned out the reverse, who would have wondered? We should readily have explained it, that it arose from ill impressions from without. But the wonder in this case is, that in spite of evil example, here is a mind capable of emancipating itself by the most violent of all remedies that young people generally take, that of separation from parents and household by flight.

"Stimulated by Winstanley's example and warned by his errors, Rudyerd erected a light, simple and masterly in its design and execution. Indeed, Winstanley's light was full of defects, and the wonder is, it ever stood as long as it did.

"Rudyerd's work was most workmanlike, an admirable specimen of carpentry. A circumstance occurred during its erection, so creditable to Louis XIV, then King of France, that it is worth mention here. There being war at the time between France and England, a French privateer one day seized all the men employed upon the rock and carried them off as prisoners to France. The capture coming to the ears of the king, he ordered the prisoners released, and sent them back to England with presents, declaring 'that though he was at war with England, he was not at war with mankind.'"

Beyond this, we have no story to tell of the execution. Hazardous and difficult it undoubtedly was, but with men and means and Government aid to back them, and with the foothold won by Winstanley at such infinite pains, the work was comparatively easy. "The whole building," says Smeaton, "consisted of a simple figure, being an elegant frustum of a cone, unbroken by any projecting ornaments or by anything whereon the violence of storms could lay hold." The work was finished in 1709, and withstood the fiercest gales for a period of nearly fifty years. It might have been standing even now, indeed, but its chief defect was that it was made, like Winstanley's, of wood, and on December 2, 1755, from some cause, never satisfactorily ascertained, it took fire and was completely destroyed.

* * * * * * * * * *

We have left, all this while, our rock again bare, with the waves sweeping freely over it, meeting with no obstacle. Again a fresh attempt is made, and this time JOHN SMEATON leads the attack.

Smeaton, like Watt, was originally a philosophical instrument maker, and one of the greatest of those great men who have contributed to make engineering the honorable profession it is today. Watt himself always spoke of him in terms of sincerest admiration, calling him "father Smeaton." Writing to Sir Joseph Banks, he said, "In justice to him we should observe that he lived before Rennie, and before there were one-tenth of the artists there are now. *Suum cuique;* his example and precepts have made us all engineers." Robert Stephenson said of him long after, when engineers had covered the land and sea with the results of their brilliant labors, "Smeaton was the greatest philosopher in our profession that this country has yet produced. His mind was as clear as crystal; and, to this day, there are no writings so valuable as his in the highest walks of scientific engineering. When young men ask me, as they frequently do, what they should read, I invariably say, 'Go to Smeaton's philosophical papers, read them, master them thoroughly, and nothing will be of greater service to you.' Smeaton was indeed a very great man.

"Such is the testimony of those competent to judge as to his professional abilities. In his character he was persevering, industrious, and unassuming. When, in the height of his fame, the Princess Dashkoff urged him to go to Russia and enter the service of her Empress, holding out to him very tempting promises of reward, he politely refused. No money could tempt him to leave his home, his friends, and his pursuits in England, 'Sir' exclaimed the Princess, with all the amiable enthusiasm of her sex, 'I honor you! You may have your equal in ability, perhaps, but in character you stand alone. The English Minister, Sir Robert Walpole, was mistaken, and my Sovereign has the misfortune to find one man who has *not* his price.' "

Of his domestic character, his daughter has left on record the following charming picture: "Though communicative on most subjects and stored with ample and liberal observations on others, of himself he never spoke. In nothing else does he seem to have stood more single than in being devoid of that egotism which more or less affects the world. It required some address, even in his family, to draw him into conversation directly relating to himself, his pursuits, or his success. Self opinion, self interest, and self indulgence seemed alike tempered in him by a modesty inseparable from merit—a moderation in pecuniary ambition, a habit of intense application, and a temperance strict beyond the common standard. Devoted to his family with an affection so lively, a manner at once so cheerful and serene, that it is impossible to say whether the charm of conversation, the simplicity of instruction, or the gentleness with which it was conveyed, most endeared his home—a home in which from infancy we cannot recollect to have seen a trace of dissatisfaction or a word of asperity to any one. Yet with all this, he was absolute! And it is for casuistry, or education, or rule, to explain his authority; it was an authority as impossible to dispute as to define."

Such is the opinion of those competent to judge as to his character, and such was the man who then brought all his powers to the work before him. The beautiful traits of character above portrayed were as much an integral part of the brilliant success he attained as his professional abilities themselves. Again, we have a striking illustration of the fact that opportunity, though it finds the man, does not make him. Let us now pass from the man to the deed.

He started out with a stroke of genius. He boldly proclaimed that the new light should be of stone! We can scarcely comprehend today what an innovation this was. We should probably say, "Why, of course, it should be of stone! of what else would you build it? What is so durable, so substantial, so reliable, so solid! Has not one wooden

structure been already destroyed by storm and another by fire? Would you repeat these disasters?" But stone, though durable, is brittle. Though solid in the main, it is weak in detail. "How bind the blocks together so that they may sustain such mighty shocks as they will be exposed to! Neither mortar nor cement can be relied upon for this, as we well know, and how else can they be fastened? The project is impracticable. It is rash. We have no precedent to guide us." All of which was quite true. But just here was Smeaton's originality shown, for the results of which we have to thank him today. He treated his brittle, stubborn material with all the ease and freedom of wood. He notched it, and grooved it, and fitted it, and wedged it, and bound it, and under his treatment it proved plastic and tractable. Smeaton was the first man to erect a stone lighthouse in such an exposed position, and to show how the thing could be done. To any one who knows the tenacity with which artisans hold to old methods and old rules, especially the capacity in that direction of the British workman—a capacity equalled only by that of the American mule—the fact that Smeaton actually carried through his novel ideas to full completion will be considered not the least of his great achievements and the strongest of testimonials to his strength of will and force of character. His originality shows strongly in his treatment of his stubborn material. He had no precedent to guide him. Every step was new. A skilled workman himself—another instance of unconscious preparation for a great work—he trusted the execution of his ideas to no one, but with his own hands he made his model, cutting and carving every part of it himself. Concerning his action in this respect he remarks: "Those of my readers who are not in the practice of handling mechanical tools themselves, but are under the necessity of applying to the manual operations of others, will undoubtedly conclude that I might have saved much time by employing the hands of others in this matter, and on the idea of the design being already fixed and fully and accurately as well as distinctly made out, that is, supposing the thing done that was wanted to be done, it certainly would have been so, and had I wanted a duplicate of any part or of the whole when done, I should certainly have had recourse to the hands of others. But such of my readers as are in the use of handling tools for the purpose of contrivance and invention will clearly see that, provided I could work with as much facility and dispatch as those I might happen to meet with and employ, I should save all the time and difficulty, and often vexation, mistakes, and disappointments, that arise from a communication of one's own ideas to others; and that when steps of invention are to follow one another in succession and dependence on what preceded, under such circumstances, it is not eligible to make use of the hands of others."

This was one great secret of his success. He put his own ideas into tangible shape himself. The stones of each course were ingeniously locked to each other and to those above and below, very much like the blocks in a Chinese puzzle. Thus, however great the force of the waves, no stone could be displaced or dislodged. The whole was a solid monolith—solid as if cut from a single block of stone—durable as the rock upon which it rested. Such handling of stone was never seen before. With caution and infinite pains and thoroughness he went slowly along, superintending every smallest detail in person, trusting nothing to chance or to others that he could do himself, leaving no weak spots, taking nothing for granted. Every stone was cut and fitted and numbered on shore and set in its place, before it went out to the rock. Thus if it met with disaster on the way, it could easily be replaced. For the shape of his tower he chose the curve of the bole of an oak tree as his model, a shape fashioned through centuries of storm and stress by the very elements he combatted. He gave additional firmness to the stones dove-tailed into the foundation rock, by means of oak wedges and cement inserted between each. In addition to this, a couple of holes were bored through every stone and oak trenails driven through and made fast, so that, says Smeaton, "no assignable force, less than would by main stress pull these trenails in two, could lift one of these stones from their beds when so fixed, as all agitation was prevented by the lateral wedges." In the same careful, thorough manner every course was laid; and on the 16th of October, 1759, those who still persisted that no building erected of stone could possibly stand on the Eddystone, might have seen shining through the night, a light which from that day to the present time has never failed.

Smeaton followed up this fine performance by another quite as fine in its way, and one which seems to have taxed his powers quite as much. He did what every engineer who completes a novel work of magnitude owes it to his profession to do—he wrote an account of his work. The unpractised writer says in his Preface, "When I commenced the composition of this work, as I had then written several essays in the Phil. Trans., in which I had been happy enough to make myself understood, I did not suppose it a matter of difficulty to give a distinct account of the progress and structure of the Eddystone lighthouse. But I now find reason to change my first opinion, and am convinced that to write a book, even tolerably well, is not a light or easy matter. In truth I have found much more difficulty in writing than I did in building. When I consider that I have been employed full seven years, at every opportunity, in forwarding this book, having

all the original draughts and materials to go upon, and that the production of these original materials as well as the building itself were dispatched in half that time, I am almost tempted to subscribe to the sentiment adopted by Mr. Pope, that:

"'Nature's chief masterpiece is writing well.'

"It is true that I have not been bred to literature, but it is equally true that I was no more bred to mechanics. We must therefore conclude that the same mind has in reality, a much greater facility in some subjects than in others."

Nothwithstanding these modest words, this Report of Smeaton stands today as a model of all that such a Report ought to be—a masterpiece of engineering literature, even as the work itself was a masterpiece of execution—full, complete, well proportioned, and written in a style at once clear and attractive. We must therefore conclude that natural facility or aptitude lies more in the capacity for taking pains than in birth; more in training than in nature; that a man is not always the best judge of his own merits or work; and that here is a man, who doing thoroughly, earnestly, and with pains, whatever he found to do with head or hands, could do nothing ill or imperfectly, and yet withal, so modest as not to be aware of his own excellence.

And now in its turn Smeaton's light has had to come down to make way for another. This is not because of any inherent defect or weakness in the construction, for it is as solid today as the day it was erected; but because the ceaseless action of the waves has undermined the very rock upon which it stands, until the foundation has become precarious. With characteristic fickleness the winds and waves have changed their allegiance, and from being the allies of the rock have become its enemies. Smeaton's tower has actually shown itself more durable than the rock itself; and now that it must come down and another upon a safer site take its place, the best tribute to his skill and genius is that the most eminent engineers of today can devise no better plan than to erect the new light substantially according to his own designs and in the manner which he was the first to devise.

There have been many lights built since then in many dangerous and difficult places. There have been many as hazardous and difficult to build as this, and requiring a courage as great to execute. The age of stone has passed, and we build them now of iron; and among the long list of those, both stone and iron, which guard our own coasts today, are many which can tell an honorable tale of dangers encountered and difficulties overcome and perseverance rewarded. If I have made much of the present case, it is that I feel that to the pioneer who boldly pushes out into unknown regions to meet unknown dangers

belong both a credit and an interest peculiar and not to be shared by those who follow in the path already trod. The deeds of unselfish philanthropy and heroic self-sacrifice, whence this tower has sprung, are not so common that it will be considered a waste of time to dwell upon them tonight, nor will it prove unprofitable to contemplate their outcome. Winstanley's work and life and death were noble, and he has indeed a worthy tombstone! So long as the earth endures, the Eddystone shall not lack its warning light, and through all time, not a year will pass that Winstanley's death will not prove the life of thousands. Well has Cicero declared, with equal truth and beauty, in his essay, *De Senectute,* "The brief space of life is long enough for worthy and blessed living." Let Winstanley's life and work and death point the moral for us. To live through all the ages, thus saving life and property, a blessing to one's fellows, an honor to one's nation, an ornament to one's profession, a benefactor of the world, is a lot given to but few, and a reward beyond the power of wealth to bestow. The world has seen few greater victories, and that stately monument reads lessons to us all.

A profession which holds out such prizes is worthy the cultivation of our brightest intellects.

Kindly grant me your indulgence for a few moments longer, that I may at least point my moral, if not adorn my tale.

To those of us who belong today to the noble profession of Winstanley and Smeaton—and it may well be that there are many such here tonight—our story possesses indeed a peculiar interest.

We know it to be a profession, and our story emphasizes the fact, in which success must be commanded by the thorough and the honest and the true. One cannot play and dally with Nature. No dialectics and acute hair-splitting and subtle special pleading will avail us here! The forces of Nature, which we must make use of or combat, restrain or utilize or subdue, are relentless, merciless to error or ignorance or sham, silent and sure and pitiless as death; and under their remorseless scrutiny, no weak spot can be hidden or covered up, no blemish but must come to light. The most thorough preparation and the sternest, surest, logical methods known to man are here none too good, and they must be guided and wielded by no prejudice nor prepossessions. No carelessness here—that is punished as a crime. No settling of vexed questions by authorities however high—truth yields to no authority. The doctor—(I intend no flippant disrespect of a noble profession)—the doctor may bury the results of his experiments underground and out of sight. The lawyer may hang or imprison his. The theologian may hide his errors in the dark obscurity of

dusty shelves. But we must publish ours to all the world—from the very housetops. There is no escape, and no evasion is possible. Decay and rust and the sharp tooth of time will eat up our most favorite theories and destroy our pet hypotheses. They will search out and bring to light and hold up to criticism every faulty performance. Talk avails nothing here and polemics are idle. Nothing will serve—nothing can serve—but the exact truth, both in conception and performance—truth external and truth internal—truth in the very inward parts. Every falling bridge and crumbling tower and sliding wall and broken arch and bursting dam and torn embankment and sinking ship and burning building are but so many illustrations of this fact. Nature's forces are good servants but poor masters. It behooves us to know them and to heed them; for when we fail, they will neither hush up nor condone our ignorance or dishonesty.

The practice of such a profession tends to make honest men. Honest not merely morally—not merely morally, for that is comparatively common—but *mentally* honest; a very rare result indeed, and one only to be attained by the severest training, and which no mere morality can ever teach, enforce, or secure. Indeed, are not our accepted moral teachers just here most generally and peculiarly found wanting? How many can say truthfully that they guard against error from within as closely and as carefully as from without—from mental sin as jealously as from moral contamination—that they hold sentiment in suspicion and under habitual control, and are altogether free from the "unpardonable sin" as John Fiske well calls it, of "letting preference tamper with judgment"? It is just this lesson which our profession pre-eminently teaches, and this result which it enforces, by the severest penalties, far more strictly than any purely moral teaching can ever do. Causing us habitually to scrutinize our own conclusions and pet theories and most cherished opinions, and even our very mental processes themselves, as closely, as pitilessly, and as disinterestedly as ever the most moral man his neighbor's faults. No academic shades, no classic erudition, no study of old masters, no eloquent sermonizing, no moral exhilaration, no religious fervor, can ever teach this lesson or procure for us this crowning result of culture and true training. It is only to be gained in the stern school of experience and realities, where responsibility is direct and punishment swift and sure, and judgment is just and untinged with mercy, and error is without appeal.

The achievements of such a profession speak an eloquent language to him who can understand their voice. For such, there are indeed books in the running brooks and sermons in stones. Consider any construction of the engineer or mechanic! It is an embodied thought!

Intelligence speaks in every curve; every detail has its meaning and its purpose; every member is a visible idea—the whole is an illustrated lecture. Reason and thought and design stand out in tangible shapes which speak to us no less than the printed page. And they speak a lofty language too! In this sense and spirit we may find, even in a lighthouse, a crystallized song, and in a steam engine an epic poem.

The study of the history of such achievements will richly repay the student. He will find in many an humble building the visible embodiment of a brave, true life, and the fitting monument of a noble death—its very mortar, it may be, mixed with blood, and human hearts and hopes and high aspirations built into the very courses of its walls!

My story is finished. I have chosen to make it rather biographical and historical than technical and scientific. I have dealt with men and deeds, as I said I would, rather than with facts and figures—with principles rather than with statistics.

A novelist whom I love to read opens one of his finest efforts, and to my mind, one of the most powerful sketches of the day, with these words—"Not a day passes over the earth, but men and women of no note do great deeds, speak great words, and suffer noble sorrows. Of these obscure heroes, philosophers, and martyrs, the greater part will never be known till that hour when many that were great shall be small and the small great; but of the others the world's knowledge may be said to sleep; their lives and characters are hidden from nations in the very annals that record them. The general reader cannot feel them, for they are presented so curtly and so coldly; they are not like breathing stories appealing to his heart, but little historic hailstorms striking him but to glance off his bosom; nor can he understand them; for epitomes are not narratives, as skeletons are not human figures."

And then in his charmed pages the past comes back to us, dry bones take shape and substance, and the shades of those long passed away revive, reclothe themselves in flesh and blood, and, guided by the master's magic hand, live and move and breathe and act and find their way to our hearts and to our sympathies.

The spirit and the inspiration of this text have determined my treatment of this evening's lecture. I have not aimed to give a scientific or technical presentation of this great work of engineering skill—Smeaton has done that for you much better than I could hope to—but I have thought it fitting, in this year when Smeaton's light in its turn must come down to make way for another; myself a member of that profession which Smeaton and Winstanley have so adorned; speaking, it may be, to many of those who, like Winstanley and Smeaton, are

mechanics and proud of their calling; to take one of these little "historic hailstones," to try if perchance my feeble breath might melt its ice, and drop it back to the past whence it came—a little tear in tribute to a brave man's memory.

No stone in Westminster Abbey tells his story or records his deeds; but far out at sea, in a grander temple not made with hands, beneath a vaster dome, "whose quenchless lamps the sun and moon supply, whose choir the winds and waves, whose organ thunder"—nobly breasting the wind and gale; sending out through the darkness and the night its saving rays; preaching to all the ages its lofty sermon of courage and perseverance and high endeavor and patient toil rewarded—(a visible embodiment of the motto of this College—"Lux et Veritas"—) there stands today, a shaft of stone as solid as the rock on which it rests—and that is Winstanley's fitting monument!

THE OPPORTUNITIES IN THE ELECTRICAL BUSINESS.

By

Dean George A. Damon.

The Editors' reasons for including this paper in their second edition are as follows:

First. It is a well-thought-out, forceful production which will prove of real benefit to many readers. In spite of its being eight years old, its teachings are just as valuable today as they were when written.

Second. It is specially applicable to electrical engineering students and young electrical engineers, and this book aims to serve students and young practitioners in all branches of engineering.

Third. It is written eminently from a business point of view—a feature that is worthy. perhaps, of more consideration than was given it in the first edition.

This paper was presented at the first meeting of the electrical section of the Western Society of Engineers, held March 18, 1904.

Mr. Damon is eminently fitted for handling the subject of his address, because he is simultaneously a practising electrical engineer and an instructor, holding the positions of Western Representative of The Arnold Company at Los Angeles, Cal., and Dean of the Engineering Department of the Throop Polytechnic Institute in the neighboring city of Pasadena.

He graduated from the University of Michigan in 1895 with the degree of B. S. E. E.; and after a general practice of five years he became associated with the Arnold Company at Chicago as their Managing Engineer, and has remained with that Company ever since, removing to the Pacific Coast in January, 1911.

Editors.

THE OPPORTUNITIES IN THE ELECTRICAL BUSINESS.

By

Dean George A. Damon.

The electrical business is a complicated one, and is constantly undergoing changes. By the time a method or system becomes standard enough to be looked upon as a precedent, a tendency develops in some entirely new direction. The men who succeed in electrical work must therefore be quick to grasp the lessons of the past, must be ready to appreciate the limitations of the present, and, above all, should be alert to seize the opportunities for improvement.

The leaders in the various branches of the industry during the first developments, when electrical work was an art and not a science, were graduates from the well-known university of "Hard Knocks." The men of the second generation of workers who are now doing things are largely the product of a semi-scientific training in schools of technology, supplemented by experience of a practical nature picked up in a more or less hap-hazard way. A few years more will see the development of a third and better prepared generation of electrical experts, and it is safe to say that they will be the result of a combination of a practical training thoroughly mixed with a theoretical education. As it must be expected that the next generation will be superior to the present one, will it not be well to stop for an instant in the strenuous rush for results and make a few suggestions which may be of assistance to our successors in planning their life work?

"Work harder," "dig deeper," "put in a better concrete foundation," are the key notes of the suggestions which our older brothers give to us as the result of their experience, and the ambitious young man will be quick to recognize the value of their advice. But what is wanted most is some definite information as to how to spend the time devoted to preparation in the most efficient manner, and how to get the benefit of a combined training in theory and practice in the most effective way.

Three Inquiries.

That those who have traveled well on their way toward their goal will have many opportunities to point the way to the ones behind, is well indicated by recounting several recent conversations. The first was with a boy of eighteen.

"I am a Senior in the High School," he said, "and I want to become an electrical engineer; what shall I do?"

He was strong, bright, ambitious and willing to work.

"Some men tell me to take a college course first and enter practical work afterward; some tell me to get a few years' experience first and then take a college course, while still others tell me to study several years, work a year or two, and then finish my Senior year. In planning my course should I include the language studies or cut them out in favor of shop, laboratory, or commercial courses? Should I try to get through in three years, or should I extend my college education over a period of five years? Others tell me to leave out the university work entirely, go to work in the shop or upon construction work, getting what theoretical training I require by attendance at night school or by taking a correspondence course. What shall I do?"

And there are some of us who will appreciate the young man's bewilderment.

The second conversation was with a professor at the head of the electrical department of one of our leading universities.

"I feel highly complimented," he said. "I have received a letter from one of the largest electrical manufacturing companies in this country, offering positions to my entire Senior class. This is remarkable, for in Europe it is the custom for the technical graduates to pay for the privilege of entering the shops of the large companies. But," he continued, "I should like to find out whether or not I should advise my boys to accept this offer. What has become of the young college men who entered the shop courses in years gone by? Are they advancing as satisfactorily as the graduates who found positions in other parts of the field? Have the large companies taken care of the graduates of their testing departments with sufficient liberality to justify a young man in making the sacrifices which a shop course entails? Would it not be better all around if I offered the large company the services of my Junior class for one year? What would you advise?"

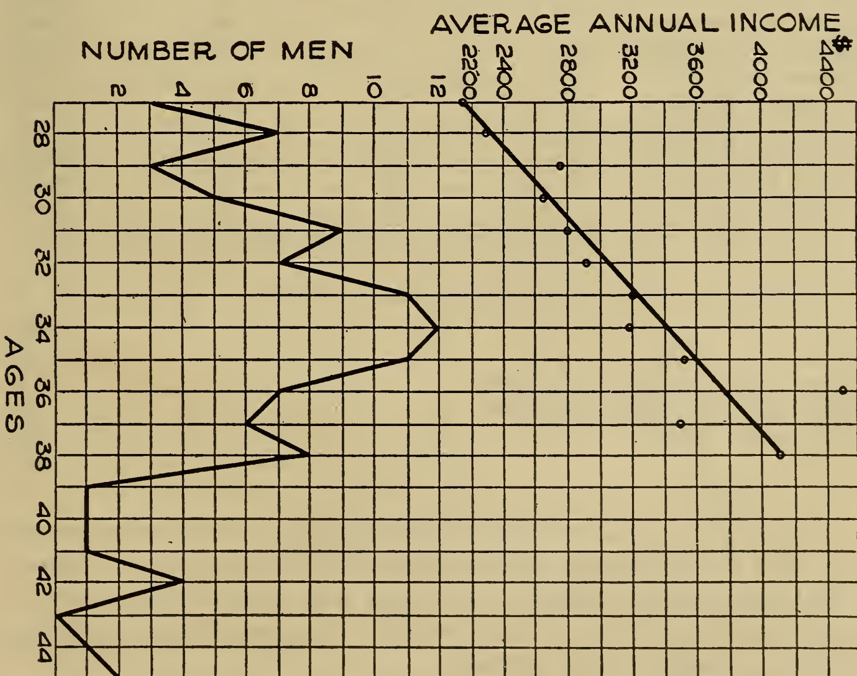
The professor is to be commended in his search for information, and in his evident interest in seeing his "boys" get a fair start in the strenuous race in which they have entered.

The third conversation was with a young electrical engineer who had graduated from high school, had then taken a college course with some practical work during vacations, and had then entered a large factory as a "special apprentice."

"I have had a fine experience," he said, "and have nothing to regret. Upon leaving college I went into the testing department of a large electrical manufacturing company, was promoted rapidly, and finally

advanced into the engineering department. My compensation at first was small, but it has gradually been increased until at the end of five years' service I am receiving about $1,500 per year. I am looking out for the future, however, and am not entirely satisfied with the prospect. If I stay with my present employers, the manufacturing company, my work must be narrowed to one department of the work, and I shall always be a salaried man without an opportunity to acquire an interest in the business. Would it not have been better for me to start with a smaller company, and is it too late yet for me to begin over again? What would you suggest?"

Knowing that the leading electrical men of Chicago would afford a valuable field for studying results and would welcome an opportunity to help furnish a solution for the problems of the boy, the professor, and the rising young electrical engineer, a letter of inquiry was sent to one hundred of the leading men in Chicago engaged in the various branches of the electrical industry. An opportunity was given at the same time for the expression of opinion on various questions pertinent to the general subject. The response to the circular letter was hearty and spontaneous, and we are under obligations to one hundred of our friends who have so kindly consented to become living examples, and willing to be analyzed for the good of the cause. The following is:



An Analysis of Results.

Young men control the business. The inquiry was, therefore, confined to men between the ages of 27 and 45, upon the theory that the older men are the product of a set of conditions which have passed away, while the youngest men are, as a rule, still engaged in a period of preparation. The number of men of each age is shown graphically. The average age is thirty-three and one-half years.

The average income at each age is also plotted on a gunshot diagram and a line of average incomes determined up to the age of thirty-eight, after which there were not sufficient data to locate the curve. This income curve starts with a value of $2,170 at twenty-seven and extends to $4,000 at the age of thirty-eight. The average income of the entire one hundred men is $3,440 per year, which will give us a standard by which we can measure the different branches from a mercenary standpoint.

The hundred men may be divided into groups as follows:

	No. of men	Average Age	Average Income
Salesmen	7	33	$2,400
Sales Managers	11	36	3,400
Business Men	10	36	4,800
Sales Engineers	8	35	2,350
Electrical Engineers	16	33	2,800
Constructing Engineers	6	33	2,850
Electrical Experts	8	33	3,200
Operating Engineers	3	32	2,250
Operating Managers and Superintendents	10	34	3,550
Professors and Editors	8	34	2,500
Patent Attorneys	4	32	4,000
Consulting Engineers	9	40	6,400

Total number of men, 100. General Averages: age, 33½ years; income, $3,440.

Classified in reference to incomes, the record is as follows:

	Men
Income over $10,000 per year	5
Income between $5,000 and $10,000	9
Income between $2,400 and $5,000	66
Income below $2,400	20
Total	100

It should be stated that there are in Chicago at least one hundred more men in the business whose incomes will average about the same as the first hundred selected. An effort was made to make the list representative, and the men were selected on account of their positions without reference to their incomes.

It is to be understood that the dollar is not the most desirable standard by which to measure men individually, but looked upon as a class, a study of the averages furnished by the inquiry is interesting and may be made instructive.

Salesmen who have technical ability or possess engineering information, as a rule, get better salaries than those who do not.

Add initiative and executive ability to the salesman's ability and he becomes a sales manager with a still greater reward.

Enterprise and energy put the man in possession of his own business, or often result in a partnership arrangement. A technical man without the commercial instinct is only fairly well paid. Ability to develop new methods or apparatus puts him in the expert class where the rewards are greater and in proportion to his ability.

Routine work, such as operating, is the least remunerative work of all. Operating managers and superintendents, however, are very well paid.

The editors were classed with the professors as there were too few to form a class with an average of their own.

Our professors should form a union, as they are certainly entitled to higher compensation, and as we all appreciate their value we would help them win should they decide to strike. We must grant, however, that they get rewards in seeing the living results of their work, which is a compensation worthy of considerable sacrifice.

The phenomenal development along all electrical lines, and particularly in the telephone business, makes the profession of patent attorney a paying one for those who are qualified for that kind of work.

The field of consulting electrical engineering looks attractive, but it will be noted that the average age is greater in this branch than in the others, which means that the successful consulting engineer brings to his work years of experience, and that it is, therefore, not a branch to be adopted at once by the young man.

Forty per cent of the men in the list are employed by what might be termed the "large" companies, such as the Western Electric, Chicago Edison, Chicago Telephone Company, etc.

Thirty-five per cent of the men either control the business in which they are engaged or own a partnership interest.

Twenty-five per cent of the men are not college graduates.

Twenty per cent of this hundred successful men never had any college education whatever.

The average age of the twenty men who are succeeding without a

college education is 36 years, and their success, measured by a monetary standard, shows an income of $3,670 per year.

The average age of 16 graduates of Cornell is also 36 years, and their success, measured by the same questionable standard, is $4,940, which shows a balance of $1,270.00 per year in favor of a college education.

It will be noted, however, that the twenty men without the education are getting along financially slightly better than the general average of $3,440 per year. This is explained by the fact that in their number are included several men who are prospering as a result of their business enterprise.

There are few non-technical men engaged in the strictly technical end of the business who reach the average income.

There seem to be more openings for the man without a college training in the telephone field than in any other.

The inquiry into the domestic arrangements of our hundred examples shows that 75 per cent of them are married. The families are composed of 45 boys and 30 girls.

Out of the hundred men selected only 56 per cent belong to the American Institute of Electrical Engineers.

The answers to the questions upon which an expression of opinion was asked resulted as follows:

Eighty per cent are inclined to think that a college education is essential to the highest success.

Seventy per cent are in favor of the technical graduate taking a shop course in a large manufacturing company, but many wished to limit this course to one year.

Fifty-five per cent are of the opinion that, in choosing a life work, better chances for advancement will be found with the smaller companies.

Seventy per cent are in favor of requiring a year's practical work of the student before graduation.

Fifty-five per cent agree that the larger companies would be consulting the interest of the art at large by offering an apprentice course open to students during an intermission of one or two years before completing the Senior year.

Opportunities.

Each of the hundred men included in the inquiry were asked to name the three fields which he considered most promising within the immediate future, and the votes received are as follows:

Electric Railway Work	63
Telephony	36
Transmission	30
Electro-Chemistry	29
Power Applications	21
Lighting Developments	12
Manufacturing	11
Central Station Work	9
Patent Law	6
Consulting Engineering	6
Contracting	5
Management of Properties	5
Storage Batteries	4
Reconstruction of Plants	3
Mining	3
Metallurgy	3
Turbines	2
Wireless Telegraphy, Designing, High Speed Telegraphy, Underground Conduit Construction, Isolated Plants, Train Lighting, and Municipal Lighting, each	1

As a result of personal observation, tempered somewhat by the opinions of the electrical men with whom the questions have been discussed, the writer wishes to present the following conclusions:

A College Education.

A young man wishing to succeed in any branch of electrical industries makes a serious mistake if he fails to use every effort to obtain a technical education. A college course is becoming easier to obtain, and it is already recognized as a general requirement for advancement. A young man of high aspirations, who is so situated that he cannot secure a university course, might better, nine times out of ten, take up some other branch of work which is less intricate than the electrical art. Thomas Edison, the Dean of the profession, is not a college man, but a gold medal bearing his name is to be given hereafter each year to the college graduate presenting the best thesis, and this incident is the best evidence of the present tendency toward technical education. Nearly every man who is now making his way in the electrical business without a college training, if asked what he would do if he had his life to live over will say: "I would secure a technical course in the best college I could find."

Correspondence Schools.

A technical course in a correspondence school which can give the proper training for an electrical engineer is yet to be produced. The correspondence schools are doing a good work and are to be recommended to those who cannot possibly avail themselves of a college course

or get instruction in evening school, (courses such as offered by Armour or Lewis Institutes) ; but a young man who will deliberately choose correspondence instruction, if anything else is available, is making a serious mistake. Of the hundred men in the list only two had completed a correspondence course. These two men were engaged in telephone work, and both voted in favor of a college course.

Practical Experience.

Practical experience is as essential as theoretical training. Too little attention has been paid by students in getting into thorough contact with the way things are actually done. This is the result of the general practice of allowing the young man to shift for himself. "I can't get a job without experience," he says, "and I can't get experience without a job;" and then, more or less discouraged at the outlook, he takes the first opening which presents itself, and it may or may not be the kind of work for which he is fitted. What is needed is a general clearing-house of information, a closer union between the ambitious student and the successful men who have been pioneers in the work. The electrical business has now progressed far enough so that the actual experience essential for the highest success along any one of its various lines can be generally indicated by experts familiar with the ground to be covered. It is time, therefore, to abandon a thoughtless and perhaps selfish attitude toward the beginner and make some organized effort to map out the territory which he must travel with guide posts and signs marked: "This Way to the Front."

An association of thoroughly successful men should exercise some supervision over the preparation of the coming generation. If it is true that the art is suffering today from a lack of trained men ready to take up and solve the problems which are all about us, what must we expect of the morrow with its widening opportunities? The student branches of the American Institute of Electrical Engineers and the recently formed Edison Medal Association are moves in the right direction, but are only a beginning toward realizing the possibilities. Considerable attention is being given to develop the best technical course, but a college training is less than half of an education. What constitutes the other half is a big problem waiting for a comprehensive answer.

Shop Courses.

The policy of the large companies in offering apprentice courses and opportunities for experience in their testing departments is to be commended. This practice, as carried on in some cases, however, is to be criticised. A representative of a large manufacturing company visits a technical school, offering to give positions to all the members of the

Senior class; the professor is highly complimented at this remarkable courtesy, and advises his students to accept. The "shop" course usually covers a period of two years. The hours are long and the pay is small. The "experience" gained by the student may or may not justify the sacrifice. "It depends largely on the man." In the meantime the large company has a good opportunity to select the material which it requires for its own use, and perhaps twenty-five per cent of the shop graduates have reason to feel enthusiastic over the system; the others pass through days and nights of discouragement, and many leave the shop with a sense of failure, which is sure to have an influence on their future.

All men are not built alike. Then why grind them through the same mill? Should not some selection of materials be made before the mills are started, a sorting-over earlier in the process? Perhaps the mills themselves could be made a little more efficient. It does seem possible that a commission composed of the broadest men in the profession, some from the large companies and some from outside practice, could do much toward improving the facilities and present systems for "getting experience." On behalf of the students now in the colleges who have still to face the practical problems, an appeal for help, information, and suggestions is made.

The Student's Part.

The trouble with a great many young men is that they don't "find" themselves early enough in life. They fail to realize the possibilities and are not prepared to grasp their opportunities. Ambition, Aptitude, Preparation, and Hard Work are the stepping stones to successful attainment. Let the ambition to excel be deeply seated and directed along the lines of natural endowment, let the purpose be firm; and as day follows night the preparation will be thorough and the man will be known by his works. "If I had it to do over again I would pick out some definite line of work suited to my talents and work like fury" is the advice of many successful and even unsuccessful men.

The purpose of this paper is to encourage a general discussion which may be of some help in arousing the latent ambitions of the young men who have not selected their life work, by showing them the boundless opportunities of an undeveloped science; to encourage the efforts of the students in our colleges by presenting the results which have been attained by their predecessors; to crystalize the sentiment in favor of a scientific combination of theory and practice; and, finally, to give an opportunity to the men on the fighting line to point the way to their successors, who must come to the front prepared in every way, if they intend to take some part in the phenomenal developments which are to be expected.

In order to direct the discussion along definite channels, the following is offered as a suggestion to a young man seriously considering engaging in the electrical business:

A Specification for Success.

In general—The purport and intent of this specification is to cover the labor and material required to produce, in complete working order, a man prepared to attain his own ideal of success in that branch of electrical work which he may elect.

It is to be understood that the omission of the mention of small details in this description does not obviate the necessity of their being furnished. What is wanted is a thoroughly trained, well seasoned, broad minded man, complete with an individual character, a strong intellect, and a sincere purpose.

Plans—He will form his ambition early in life.

He will take a natural interest in the history of men of eminence in his chosen work; and their achievements will inspire him with a desire to accomplish great things.

He will develop his imagination and constantly broaden his conception of his own possibilities.

He will seek to learn what the world wants and then will endeavor to train his natural abilities so as to supply that want.

Foundations—He will, as a boy, develop a knack of "doing things," either as a mechanic, as a draftsman, or in some boyish business enterprise, and a combination of any two or all three proclivities is desirable.

He must early learn the advantage of doing some one thing well, but he should not allow praise for his proficiency to encourage him to neglect study along the lines he does not naturally fancy.

He will prepare for college, and during this period of preparation he will get enough experience in practical work to demonstrate that he has made a wise choice for his life work.

He will not let the attractions of practical work interfere with his intentions to secure the best theoretical and technical training the country affords.

Dimensions—He will endeavor early to "earn money" by doing useful work, and will seek employment outside of his study hours. Everything he attempts he will complete to the best of his knowledge and ability.

He will put himself on a self-supporting basis as soon as possible, and will earn his own way through college. If he receives financial assistance, he will treat it as borrowed money, to be returned, and he will keep the debt within reasonable limits.

He will not allow any false sentiment "to finish with his class" prevent him from stopping out one or even two years during his college course in order to add to his store of practical experience along electrical or allied lines.

He will determine for himself whether he intends to realize on his possibilities quickly or whether he will lay a broader foundation for a slower but higher development.

General Design—Each bidder will state the percentage which he is prepared to guarantee in connection with the following qualities:

Health	Self-respect
Ambition	Self-reliance
Honesty	Courage
Truthfulness	Observation
Temperance	Common Sense
Decision	Initiative
Purpose	Enterprise
Up-to-dateness	Enthusiasm
Originality	Concentration
Energy	Executive Ability
Industry	Scholarship
Stick-to-itiveness	System
Judgment	Tact
Good Manners	Neatness
Self-control	Thoroughness
Patience	Dispatch
Cheerfulness	Grit
Capacity for Hard Work.	Punctuality

Consideration will be given to guarantees of high efficiency of each item. It is suggested that all of these qualities be carefully measured.

Capacity—Even if the young man possesses only ordinary talents, his capacity for hard, conscientious, intelligent, well-directed work will attract attention and win advancement.

When the occasion demands, he will be able to stand a long run on overload or respond to excessive demands for short periods without permanent injury.

He will be able to direct others and will not depend entirely upon his unaided efforts for results.

Operation—He will work quietly, and will be turning in the right direction every minute in a simple, direct, and accurate way.

He will join that great army of workers who are actually doing things rather than that smaller class of men who occupy most of their time in telling what they are going to do.

Parallel operation—As a student he will enroll as a member of the Student Branch of the American Institute of Electrical Engineers and take a lively interest in the Institute papers and discussions. In practice he will advance to Associate membership and will look forward to the day when he has added sufficient to the art to be considered worthy of Active membership.

If he locates in Chicago or in the West he will become a working member of the Electrical Section of the Western Society of Engineers.

He will make friends among his superiors, who will respect his ambitions and will be glad to assist him in realizing his ideals.

He will study men and know how to deal with them.

Work to be done by others—Parents should study their children and encourage them to develop their natural tendencies.

Teachers should get hold of their students personally and as far as possible treat each case individually.

More occasions should be made for successful men to meet students and give them the benefit of their advice and experience.

The students should not be isolated in a little world of their own, but should be brought in contact with an atmosphere of actual affairs.

Above all, some method must be devised to guide the young man to and through the course of practical experience best adapted to his qualifications and purpose in life.

Shop tests—If he enters the shop or testing department of a manufacturing company, he will make a bargain which will result in his getting an all around experience in exchange for his services; and while in the shop, he will keep on the move in every sense of the word.

He will seek to make himself thoroughly practical in all his ideas and methods of work.

Finish—He will include in his preparations considerable literary work and will seek after a general culture. He will study at least one foreign language.

He will regard his college work as only the beginning of his education and will be a student always.

He will seek practice in the art of expressing himself, and will occasionally write a paper on some technical subject.

He will become interested in some social, educational, or reform movement, and will avoid becoming a recluse interested only in his own work.

Inspection—During his Senior year he will submit a thesis in competition for the Edison Medal; and even if he fails to get the prize, his effort will demonstrate his sincerity and will show the thoroughness and breadth of his preparation.

Fittings—He will find it necessary to possess accurate knowledge of nearly every branch of science, including physics, chemistry, mathematics, mechanics, pneumatics, hydraulics, mining, metallurgy, and civil engineering.

He must know something about accounts and a great deal about business and commercial law.

He will find that the electrical business is so broad in its scope that a natural aptitude in any direction can be made of use.

Completion—He will make every sacrifice to get a thorough preparation and a broad experience up to the age of 28 or 30 years.

He will accomplish much between the ages of 30 and 45, at the end of which time he will be well settled in his business or profession.

Let us leave him at this time to inherit his own. May he live long and prosper.

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FORMULAS, THEIR USES AND ABUSES.

By

Dr. Alfred Hume.

The reason why this paper was not included in the first edition is that the Editors considered that, notwithstanding its evident importance to young engineers, it would not be read to any great extent by engineer-students. On account of the probable demand for the work by young practicing engineers, they have concluded to insert it in the second edition, knowing that the advice it offers is of the soundest, and that if it be followed, much trouble will be avoided.

The Editors in their practice have always observed the rule, never to use a rational formula of which they have not for themselves established the correctness, nor an empirical one with the derivation of which they are unacquainted; and they have given such instructions and advice to their assistants and young engineer friends. No engineer of reputation can afford to accept blindly the findings of other engineers and employ them in his work. In the case of rational formulas, to do so would be an acknowledgment of mental inferiority; and in the case of empirical formulas, it would involve running too much risk of mistake and disaster. In applying any formula one needs to know, beyond a doubt, the units of measure in which all the components thereof are expressed, and this he cannot ascertain without investigating; hence a study of the formula is a necessity.

Although this address may not be very interesting to underclassmen, it will do them no harm to peruse it; and certainly all upperclassmen should read it, become convinced of the correctness of its teachings, and resolve to abide by them throughout their professional careers.

The address was first read in March, 1897, before the Engineering Association of the South by its author, who was then a practicing engineer. He has since accepted the chair of Mathematics in the University of Mississippi.

It was reproduced in the Engineering Record of November 5, 1910; and in an editorial upon it there appeared the following comment: "The paper points out very clearly the danger of furnishing too much predigested mental food to young men, no matter how good their attainments may be. The technical college is essentially a place for teaching

the sciences upon which sound engineering is based. The more thoroughly the student is taught to question everything that comes before him for the first time, the better will he exercise the critical faculty which is essential for successful engineering. It is surprising, nevertheless, to observe how readily many engineers, particularly young engineers, will accept and use without question a formula for any given purpose, while the relations which are expressed in that formula, if written out and explained at length, would be rejected instantly, except for use in a very narrow field of application. For this reason it is probable that the students of civil engineering in the higher classes of our technical colleges might well be required to read at least once each half year the paper by Professor Hume. Good formulas are admirable helps, but they should never be allowed to take the place of a clear understanding of the subject to which they relate."

Alfred Hume was born at Beech Grove, Coffee County, Tenn., Dec. 1, 1866, and studied in the public schools of Nashville, then at Vanderbilt University, where he took the degree of B. E. in 1887, that of C. E. in 1888, and that of D. Sc. in 1890. For three years he taught in various departments of his *alma mater,* and in 1890 he was called to the chair of Mathematics in the University of Mississippi, where he has remained ever since. In 1900 he organized and directed the course in Civil Engineering, remaining in charge of the work two years. In 1905 he became Vice Chancellor of the University and Dean of the Academic Department, and during the session of 1906-1907 he was Acting Chancellor.

He is a member of several technical societies and the author of a number of valuable papers on mathematics and other professional subjects.

Editors.

FORMULAS, THEIR USES AND ABUSES.

By

Dr. Alfred Hume.

In the development of scientific thought there are two marked tendencies, apparently opposed, but, in reality, both natural and necessary. Diversity is the word for the one, unity for the other. The first results in the discovery of a variety of facts, the second in their unification. To the one it would seem that no bounds can be set. Who has the presumption to limit the other? Amid a myriad of bewildering chemical phenomena stands the undoubted truth of the changelessness in the sum total of material things. If the one discourages human effort, no less does the other cheer to renewed exertion. Do the fall of the apple, the ebb and flow of the tides, planetary motions, demand explanation and seem to baffle every attempt to unify them? There is a oneness here—gravitation. Do the never-ceasing transformations of energy appear to defy any law of continuity and to appeal for some principle of permanence? An infinity of change without an iota of loss is the reply. And so throughout the entire realm of knowledge these two tendencies may go hand in hand, progress depending upon their interaction. Does the one confuse, mystify? The other simplifies, clarifies. Where one staggers the human intellect, the other steadies it.

In some of the foregoing antithetical statements is a hint of one of the motives which cause men to seek broad generalizations. It is to avoid unnecessary labor, to economize mental effort. To those who can use intelligently the general truth, who can see the process by which the general was evolved from the special, there is here great gain, immense advantage, accompanied, however, by the danger of abuse.

For the engineer and the mathematician, the most lucid and concise method of expressing laws is by means of formulas. With a few symbols and a little space, a record may be made which will embody the results of ages of labor on the part of eminent thinkers and of long series of experiments. This briefest possible statement of a truth, the outcome of a course of pure reasoning, or of this in connection with experiment, is a formula. It is a picture of mental energy. It is an embodiment of thought. When properly used it is thought enthroned, otherwise, imprisoned. It is not a dungeon where thought is chained,

but rather a crystal palace where reason reigns. Used aright it is a blessing, misused it is a curse. Its true province is the preservation of truth, to the end that the user of it may have time and energy to bestow upon things above and beyond the formula.

That the engineer should employ every time-saver that he can command is at once evident when attention is directed to the vast fields yet to be explored and the marvellous growth of engineering literature on which he must keep posted. A little more than one hundred years ago a book was published, the title page of which reads as follows: "A Treatise of Practical Surveying; which is demonstrated from its first principles. Wherein everything that is useful and curious in that art is fully considered and explained." Think of it! One small book containing all that was known of the theory and practice of surveying! What would be thought of an author making that claim now for a book of a thousand pages? A mere glance at the works on surveying, ranging from "Public Land Surveys of the United States," a descriptive, non-mathematical booklet intended for children in the public schools, to the technical treatise on geodesy, will convince one that no book smaller than Webster's International Dictionary would be justified in appropriating the title quoted above. And what has been said of this subject is equally true of many others with which the engineer constantly deals. Where fifty years ago there was one volume treating of civil engineering there are now hundreds of excellent works and scores of periodicals devoted to engineering in all its branches. Surely it would be the height of folly for a worker in these ever-widening fields to deny himself any legitimate assistance, be it a formula, or what not. Unnumbered problems are to-day calling for the brain energy thus saved.

No man should be content to use a formula, the history and derivation of which he has not at some time or other become acquainted with. This does not mean that he should be able to originate it. Far from it. But, simply, that he should follow the line of thought by which it came into being. If he is unable to do this, the formula may become a dangerous implement in his hands.

The aim at reduction to a minimum of unprofitable muscular and mental exertion has led to the calculation from formulas of tables too numerous to mention. Much labor has been expended in their production. How much greater the saving for those who use them! Logarithmic tables alone have been of incalculable value. And yet men have not been satisfied with the long stride from numbers to their logarithms, but have taken another important step from these to the slide rule. Both tables and calculating machines may very properly be de-

nominated offsprings of formulas. And, because of their nature, they, too, are subject to abuse.

It is not maintained that no one should handle these things unless he fully understands them. Probably the very large majority of skilled accountants have no adequate conception of the essential characteristics of our common system of notation, without which arithmetic could not have been developed. Not many could give a clear explanation of the fundamental arithmetical processes. While doubtless many an engineer has been conscious of the well-nigh irreparable loss sustained by the deprivation of his formulas and similar helps, very few practical arithmeticians have ever realized that they would be hopelessly handicapped if confined to the cumbersome Roman system of notation. And yet, adults in practice though babes in theory, well versed in rules while ignorant of reasons, masters of the art while strangers to the science, they can figure, and with greater rapidity and accuracy than can the average professional mathematician. Surely the person who would hold that these should be forbidden the use of figures would properly be set down as a fanatic. As well might we argue that no one should breathe unless he could tell the constituents of the atmosphere; or that all should quit using water until they could make a chemical analysis of it. No such absurd position has been taken. But I do plant myself firmly upon the proposition that no one who has the time to acquaint himself thoroughly with the things with which he works, be they formulas, tables, or machines, is guiltless if he fails to do so. These, like blasting powder and dynamite, are powerful agencies, but unsafe in the hands of carelessness and ignorance.

The plea is not for less mechanical dexterity, but more intelligent insight; not that one construct every piece of mechanism by which he lessens his labors, but that he grasp the underlying principle; not that he calculate the table which he finds almost indispensable, but that he understand the process; not that he deduce the formula, but that he appreciate the course of reasoning which leads to it. The man who is willing to use that which he does not understand is tempted to invest it with a kind of magic. He is its slave, not its master. He who thus uses a formula is, for the time at least, no more than a machine. There is in this a servility discouraging independence and unbecoming one of the most dignified and learned of the professions.

In this connection should be noticed an objection, and a serious one it is, to the large number of handbooks and other helps available. The temptation is to substitute book for brain, hand for head, rule of thumb for reign of thought. A mere tyro becomes possessed with the idea that everything needful is tabulated and that he is equipped

as an engineer when he gets hold of a few tools, heedless of the fact that their office is to facilitate the execution of a project and not to create the plan. His error is like that of one who imagines that he can reproduce a landscape by manipulating a brush and stencil. His attitude is very much that of him who forgets that to be a musician implies far more than the ability to wind up a music box or turn the crank of a hand organ. Does he want the area of a section of a column or beam, its moment of inertia about the neutral axis, etc.? He looks it up in his table. Does he want a formula for pile driving? He can get them *ad nauseam;* and they will furnish such widely different results that the novice should have his eyes opened to the fact that he lacks something necessary to successful practice.

I must again emphatically disclaim all intention of belittling or underrating any of the contrivances to which reference has been made. These formulas, their developments, expansions, or accompaniments are of inestimable value. All are more or less familiar with their great utility. It is their abuses rather than their uses that we are prone to overlook. The limitations in the application of a formula are likely to be disregarded by him who is ignorant of its history and the process of its development. That class of people who have scant respect for the book-learned are not so deserving of censure as that even larger class who worship a printed page and deify a formula forgetting that it is a human product. These idolaters, whose credulity leaves no room for reason, are largely responsible for the existence of the sceptics and scorners who look with suspicion upon everything within the lids of a book. To both comes the injunction, "Prove all things; hold fast that which is good."

That the conditions to be met in order to make a wise use of formulas may appear more clearly, the following classification is added. It, like all that has been said, is suggestive rather than exhaustive. Passing by most of the formulas of pure mathematics—those of definition, identities, formal solution of equations, development of functions, etc., those of chemistry, symbols of molecules, and others which do not come within the scope of this paper—the consideration of two great classes of formulas with which engineers are most largely concerned is reached.

The first class embraces those which follow from definitions and axioms and are therefore true of necessity. Formulas for center of gravity, moments of inertia, center of pressure, etc., belong here. But is one free from the danger of misapplying them? Assuredly not. The only guarantee of proper use is a comprehension of the theorems which pertain to them. Another of this class is the prismoidal formula whose beauty and power have not always been accorded the high place which

they merit. The originator of this formula of such wide applicability, Jacob Steiner, is said to have been "the greatest geometrician since the time of Euclid." Not only does it apply to many solids bounded by plane and warped surfaces, but also to quite a large group of solids of revolution such as spheres, spheroids, etc., as well as to a vast number of others not included in the above, among which may be mentioned groined and cloistered arches. The failure to master the meaning of this remarkable formula has led to a multitude of blunders. Ignorance and prejudice have conspired against it. With all its wonderful fullness it yet has its limitations. There are forms to which it is not applicable. Well may the question be asked, Has it been most used, abused, or wholly neglected? A sound knowledge of the truth as crystallized in this formula will prevent its perversion, and will lead to its general adoption, in a modified form at least, in computing earthwork.

A very important and useful set of formulas may be considered a sort of sub-class of the general one under discussion. The reference is to such as have been obtained from others of perfect accuracy by neglecting small quantities, and which therefore lead to approximations. A simple example is the formula which states that the middle ordinate of a rail is the square of its length divided by it radius of curvature.

The second great class of formulas in constant use by engineers is the empirical. In them are recorded much that is valuable in engineering experience, and much, too, calculated to discourage painstaking accuracy and to betray over-confidence. He who runs into no error here must know his ground thoroughly. Tests in hundreds of laboratories, measurements in all quarters, are brought together and made to speak volumes in a few formulas. Here we catch a glimpse of the field of greatest activity and promise that the engineering profession is working to-day. Mathematicians have done their part, and it has been well done. But there still remains a work which is distinctively the engineer's. It is his to continue the investigation of the materials of engineering until he can use the formulas of this class with as much reliance and assurance as those of the other. Here is a task of extreme difficulty. But the obstacle which this profession cannot surmount has yet to be found.

Of this class there are two divisions. In the first are those in which the form of equation connecting the observed or given quantities and the required is known from theoretical considerations, certain coefficients being empirical constants. The formula which expresses the fact that the distance through which a body falls from rest equals the product of some constant and the square of the time, is one of this subclass. The law of dependence is known; the form of the function is

given; the times are the observed quantities, the distance the quantity whose values are to be determined, the only empirical part of the formula being the constant coefficient, one-half the acceleration due to gravity.

In very many cases, however, the form of the equation which expresses the connection between observed and required quantities is unknown and must be assumed; and we have the other sub-class, wholly empirical. As an illustration, examine the formulas that have been devised for the mean velocity of water in rivers and canals in terms of the maximum surface velocity and other variables. Not only do the coefficients differ but the forms of the equations vary greatly. So with the formulas for columns, sewer formulas, pile-driving formulas. Different investigators have arrived at such diverse results as almost to force to the conclusion that no formula can be obtained that is generally applicable. While waiting for, and confidently expecting, the discovery of the law which governs in the several cases, it behooves all who use these formulas to take care lest they abuse them. Nowhere else is the necessity for a complete knowledge of the history of a formula so imperative.

In constructing formulas, attention should be given to the following points: They should be simple rather than complicated and elaborate, resulting in ease of computation. Whenever possible (and sometimes it is) they should be so constructed as to avoid the use of factors of safety. In other words, it should be safe to use them without introducing these "factors of ignorance." Conformity with theory should be sought. Rational formulas are to be preferred. Practical formulas must be constructed from experiments involving conditions actually existing in real work. They should be so made that, in limiting cases, they will give results accordant with both theory and practice. Some, in pretty general use, reduce to absurdities under these hypotheses. Finally, great stress should be laid upon uniformity in the notation employed. If practicable, each letter should always be used to represent one and the same thing; and the symbols selected should bear some relation to the thing symbolized, as p for perimeter, m for bending moment, etc.

In the use of formulas it were well to bear in mind a few guiding principles. The desirability, yes, necessity, of intimate acquaintance with the history of the formula has already been insisted on. How else can one make sure of its applicability to the problem in hand? If empirical, ascertain whether or not the experiments from which the constants were determined were made under conditions like those which obtain in the work to which the formula is to be applied. Caution is necessary here. It should never be forgotten that a formula cannot be

used with safety in work outside the range of observed cases. Formulas resulting from experiments on small pieces are often unreliable when applied to larger ones. Those intended to be used within certain limits must not be used beyond them. In making calculations with formulas, logarithms, etc., time should not be wasted in attempting a precision and making a show of accuracy unwarranted by the character of the formula itself, the field measurements, or the degree of refinement or nicety possible or desirable in the work to which the results are to be applied. Too often mistakes are made here, and deception may be suspected where none was intended and where judgment alone was to blame. Care should be exercised in getting correctly the denomination represented by the letters, whether feet, inches, or meters; hours or seconds; pounds, ounces, or kilograms. Lastly, it is of importance that one know to which of the above classes and sub-classes a formula belongs. Such knowledge will be of no little service.

THE ELEMENTS OF EFFECTIVE EDUCATION.

By

Professor John Lane Van Ornum.

The following most instructive, valuable, and thoughtful paper was issued after the first edition of this book had gone to press, which accounts for the Editors' failure to utilize it previously. It offers one of the most profound treatments of the subject of education ever written—in fact, it may appear at first thought to be too profound for students' reading; but such is not really the case, as several careful studies of it will certainly impress upon any reader's mind many truly valuable facts and ideas. While it is possible that a large percentage of freshmen students may fail to obtain much benefit from it at first, it is certain that ultimately they will profit greatly by its continued perusal. The treatment is eminently philosophical, and on this account the address has to be read slowly and carefully with mind undisturbed by either outside impressions or wandering thoughts. It was evidently written for teachers and not for students; nevertheless, no student makes a mistake when he devotes a moderate portion of his spare time to the study of papers which are intended to influence and guide his instructors in their treatment and development of himself.

Professor Van Ornum very properly dwells at length on the necessity for developing the student's capacity for thought rather than filling his mind with useful facts and figures. In this principle lies the true science of technical teaching; for while facts and figures change from time to time and are easily forgotten, the capacity to think for oneself when once attained is seldom, if ever, lost.

Professor Van Ornum, who occupies the chair of Civil Engineering at the Washington University, St. Louis, is a recognized leader in his line of work and an authority on matters educational, all of which is an additional reason for the study of this important address. His biographical record is as follows:

He was born in Hartford, Vermont, May 14, 1864, and was graduated from the University of Wisconsin as B. S. in 1888, receiving special honors in mathematics and general honors on graduation. In 1891 he obtained the degree of C. E. from the same institution. He has held responsible positions on municipal, railway, and government engineering

works in Wisconsin, Michigan, Tennessee, Missouri, Georgia, and Florida, aggregating six years. He was Chief Topographer of the Mexican Boundary Survey from 1892 to 1894, and visited Europe to inspect engineering works and schools in 1897 and 1898. He was Major of the Third United States Volunteer Engineers in 1898 and 1899, serving in the war with Spain, and has been Professor of Civil Engineering in Washington University since 1899. In addition to his teaching, he is actively engaged in various civic enterprises and interests of St. Louis.

He is author of technical papers on Topographical Surveying, Hydrographical Surveying, Structural Engineering, Fire Prevention, and Insurance Rates, and was the pioneer investigator and writer on the subject of the Fatigue of Concrete.

He is a member of many of the leading technical societies of America, and has been President of the St. Louis Engineers' Club.

Editors.

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It is the purpose of the college to develop knowledge in such a way that the student, responding to its inspiration as the chord thrills in answer to its tone, shall discover in himself a constructive power, quickening into action. Such productive knowledge is the result of a systematic evolution, especially through childhood and youth, of various latent capabilities. Distinctive among these potential attributes, which education should make very actual, are those of a conscious individuality which finds expression in self-direction, gradually increasing in power and equipoise; and of a personal sense of duty which prepares for assuming responsibilities. The multitude of facts and conceptions form the material from which is developed the educational structure of the boy; but whether this structure adequately serves its master depends upon the manner of fabrication of these materials. A certain mass of information may be only a clog, or it may be fashioned into an effective edifice. The waters of the harbor at half-tide carry a steamship onto the bar. If the tide is falling, it lies helpless; but if rising, the vessel is freed from its impediment. The rising tide of mental capacity comes from developing individual initiative and personal responsibility as the the essential motives which vivify the training of the schools.

The child displays a marvellous capacity to master the powers of speech, of locomotion, and of those other primary faculties needed to enable him to supply the immediate requirements of his physical nature. His own initiative spurs him on in learning to talk and walk, to watch, to endeavor, to develop a startling capacity of asking "what" and "how" and "why," and gradually to think and reason about those evident things of life which directly concern the satisfaction of his physical needs and desires. In all these first years the spur, the unconsciously impelling force, is within the child himself; and his educational progress in the inherent but elementary facts of life is, therefore, thorough and rapid.

If the same need, interest, and initiative were continued through the subsequent years, undoubtedly progress would continue, even in an accelerating ratio and efficiency, rather than at a diminishing rate that often approaches stagnation. Whether one's education be in the schools

or in other institutions or experiences, that only is a true education which systematically develops and trains the mental powers in effective preparation for the duties of life. If the adequate exercising, instructing, cultivating, and coördinating of one's powers is secured by individual effort under stress of adverse conditions and outside the schools, as was true in the case of Lincoln or John Marshall, surely we can only admire and endorse the achievement, although the result was attained in a way quite unorthodox. If one fits himself for life's duties in commercial activities, as did Robert Morris; or in business affairs, as did Benjamin Franklin; or if, like Jefferson, through the aid of schools and colleges one trains his youthful faculties toward the control and mastery of the experiences of life; in any case the goal is reached in some degree of completeness, though the routes may vary. Yet, always and ever, the unvarying essential is that individual initiative, that mental craving which demands sustenance and will not be denied; making use of all agencies (whether schools or others) that offer effective aid.

The schools take the child at that particularly critical age at which the motive is less manifest. The incentive to personal effort is becoming less obvious. Through the primary and grammar school age, the increasing obscurity to the child of the purpose and value of his training is very likely to bring him to an attitude of indifference, if not of opposition. Perhaps the greatest general trial of faith which the young pupil experiences is when he is expected, in his immaturity, to orient his inner consciousness to what seems a vague (if not unknown) course. Fortunate is the child who is shown at least occasional glimpses of the less obvious domain he is preparing to share, through the wise guidance of parent or teacher, or because of the stress of adversity or circumstance.

Probably no greater service to mankind has ever been rendered than that of pioneer investigators who endeavored to disclose the essential elements of true instruction: Rousseau emphasizing the necessity of the pupil's learning through observation and experience; Pestalozzi laying stress upon development by progressive effort; Froebel adding the essential idea of developing the faculties by arousing voluntary activities; and the second principle of Jacotot affirming the truth upon which the fundamental principle must be based, that "every individual has received from God the faculty of being able to instruct himself."

The child cannot master the rudiments of the (to him) obscure realm of the mind through direct constraint from without. His own initiative must be awakened and his faith be given some conscious support on which to rest. The vivifying moisture enters the tree in response to the inner call of life and growth; water forced into it by external press-

ure would add nothing to its strength. Not the mercenaries, but the Macedonian phalanx inspired victories. External compulsion gives opportunity for defective or fruitless consequences; while a desire or demand from within constitutes the fertile field for ready development.

The teacher who fails to develop the child's initiative (which has served him so well in his mastery of the elemental attributes of life) as the child enters upon the less perceptible intellectual domain, is perpetrating a wrong that is less obvious, but no less culpable, than if he should deprive the child of needed food. A tactful, firm, inspiring guidance toward the essence of knowledge by appeal to the sensibilities, interests, desires, and enthusiasms will give heart and purpose to the young learner.

However great be the responsibility of the teacher in this regard, the obligation of the parent to guide the child's mind into a growing consciousness of the significance of the mental realm is paramount. With school privileges universal, parents easily sink into a condition of careless or indolent neglect, allowing the child to grope vaguely for the unknown truths or to lose his bearings altogether. The interest of parents is earlier devoted to protecting the child from falls, burns, and other physical injuries and pains; but he would easily learn caution for himself because of the immediately consequent physical penalties. Yet, when the child enters upon the conquest of the vague but profound mental domain, his nurture is often really left to strangers who are workmen in the child-factory whose output is of the pattern prescribed, as the subjects are passed wholesale through one department after another in non-individualizing progression. In the schools the numbers are so considerable that, with the best of intent, the general submergence of the individual child into an aggregate average is almost unavoidable, unless the parent also discharges his duty discriminatingly. This duty is not to diagram the sentences or to "do the sums," or to perform for the child his daily tasks; his exercises are the work of the child himself, and such supposed assistance is a detriment rather than an aid, substituting a dummy of expediency for the substance of real benefit. Rather is it the privilege of the parent, by virtue of his relation to the child, gradually and opportunely to disclose to the expanding spirit the purpose and significance of his tasks; to reveal the import of the work in the intangible but paramount realm of the mind; to interest and inspire the child progressively (as only a parent can) to a definite perception of the reality of those things most worth while. I apprehend that there is no greater fundamental immorality of the present day than the indifference of a parent to the wavering apperception of his child.

A youth in his teens has reached the age at which responsibilities

must be assumed in his pursuit of information. Longer to delay the inauguration of a substantial development of a distinct and personal conception of duty in its relation to life's experiences is to suspend, in equal measure, the mental and moral growth. The feeble-minded has little capacity for such accomplishment, and the idiot none at all; but the average youth should not (by reason of mistaken consideration, negligence, or misapprehension) be allowed to pattern his training after that which is fitting for either unfortunate.

The boy on the farm has his responsibilities which conduce to the development of mental capacity in a way that, in spite of less opportunity for study, often results in a more effective education than is secured by the city boy having abundant school privileges. The youth from the straitened home, subjected to the discipline of business house or factory, is obliged to rely upon his own resources if he "makes good;" and if he does not succeed, the result is, to him, conspicuously serious. His experiences with men and things directly tend to induce the development of those personal qualities of observation and concentration; of energy, perseverance, and originality; of accuracy and thoroughness; of courage and resourcefulness, which are relatively difficult to evolve in school life. Such a training of youth gives meager opportunity for study; but the far-seeing boy apprehends the deficiency, and corrects it. Self-help is forced, if this youth wins success.

On the other hand, the scholar finds the schools chiefly active in imparting knowledge. Their methods facilitate the informing more than the training of youth; they consist in offering rather than in disclosing, in giving instead of judiciously developing. The system is quantitative rather than qualitative; it tends toward dissipation instead of concentration, and it develops capacity more than capability. The result is absorption rather than assimilation, and the encouragement of a "submissive receptivity" instead of an "independent activity." "It is not the knowledge stored up as intellectual fat, which is of value; but that which is turned into intellectual muscle." Such scholastic experiences give meager opportunity for acquiring individual responsibility; but the energetic boy is conscious of the need and corrects it. Self-discipline is attained if this youth gains the goal.

In either case, the moral effect (on the personality) of conscious achievement is profound.

The difficulties confronting the employed boy, with reference to lack of opportunities for instruction, are being moderated by various manifest means. There is vastly less recognition of the equal need that the scholar encounter such discipline as will induce him gradually to assume responsibilities, definitely and unequivocally.

The duty of the teacher is not merely to enforce regularity and punctuality, order, attention, diligence, and earnestness; these are only the outward manifestations of the deeper ultimate purpose—that of awakening in the pupil an effective control of his own time and effort which makes real progress and ultimate attainment possible. Again, the copying of problems and translations, the "working for the answer," the mechanical memorizing of the text, the use of a "pony," or the utilization of the complaisant teacher or parent who thus becomes the living "pony," are but the deplorable evidence of the real malady; that of a lamentable reluctance to accept that discipline which finally develops into personal power to think clearly, reason definitely, and act worthily in the circumstances of life. In composition it is simpler to utilize the mediocre facility already attained than it is to gain added ability in exposition and diction by painstaking scrutiny and reflection; in geometry it is easier to memorize the text than to master the principles by original demonstration, closing the book after reading only the theorem; in all the daily tasks the drift is toward expediency instead of principle, the fostering of flaccidity rather than firmness of mental and moral fiber. Evasion is the fundamental delinquency of the school.

The gliding waters flow heedlessly onward toward the passive sea; only the portion which meets a designed constraint fulfills the fitting destiny of more than incidental service to mankind. The scholar who squarely meets responsibilities develops a conscious potency which qualifies him for confident endeavor.

The purpose of the college is to give the student the opportunity for acquiring a substantial capital of productive knowledge and mental power. His prior education is in preparation for this, both as regards his fund of accumulated information and his training in those attributes which equip him for consistent and effective effort. If his previous experiences in the pursuit of learning have given him a developing capacity for personal initiative, thoroughness, and responsibility (at those periods of childhood and youth when they are most readily gained), the student is well equipped to profit from his college course. The college which receives youth who are seriously lacking in these fundamental essentials must discard the hopelessly deficient ones; and, with the rest, either laboriously mitigate the fault or ignore the delinquency under the pressure of the college system. The orchard whose pruning, fertilization, and care have been slighted, may recover some of its promise by precarious processes of "forcing;" or, ignored, it produces but sparingly. In either case the fruitage induced by the sunlight and rains is both deficient and defective. The colleges and professional schools have such severe burdens in their own legitimate province that it is well-nigh impossible for

them to attempt also to assume inherited burdens, and expect success.

The advantageous assumption and natural sequence of the various duties and requisites of the complete educational training are relatively simple and effective if their import is clearly apprehended; but if their true significance is unrecognized, evaded, or regarded triflingly, difficulties accumulate until the aggregate impediment cripples the endeavor. Failure to profit adequately from a college course is even more conspicuously serious than are most failures, because that which is the manifest summit of the educational system is equally the obvious target for aggregated criticism whether induced by distrust of the distinction resulting from commanding position and large endowment; from the endeavor to shift responsibility for a delinquent graduate from all the various contributing causes to the ultimate one; or from the sturdy capacity of the capable graduate who will not remain indefinitely a mere tool in the mechanism of organized proprietorship. It is agreeable for some parents who have negelected their own part in the youth's training, to evade direct reproach by designating the college for this notice. There is a seeming expediency in charging the final factor of education with any apparent delinquency, and the floods of reproach often obscure the real situation. Just criticism is helpful; but many who sit in judgment seem to have had unfortunate personal experiences, or to employ devious processes of reasoning, or they exhibit a warped mental vision. There is occasion for improvement in the college as well as elsewhere; and all the agencies concerned may well unite in the endeavor to augment the real effectiveness of each step of the educational course.

Success in any field awaits only him who qualifies for it, and such searching tests should be applied as will most clearly disclose the fundamental aptitudes of the boy, including his capability to profit from the advanced training of the schools. Much disconcerting stress and ineffective effort would be avoided if the higher schools were less frequently regarded as the reservoir of an elixir of miraculous potency. Intellectual emaciation is not cured by augmenting the scholarly diet that has resulted in a mental dyspepsia. It would be better for the parent, the boy, the school, the college, and all concerned, if the colleges should more rigidly scrutinize the essential qualifications of applicants for admission, instead of often soliciting attendance even of the doubtful and reluctant ones whose progress is gravely problematical because personal incentive and mental vigor are lacking. The inner motive and real aptitude of the student who wins success must be more than embryonic; opportunity evades the dilettante postulant.

If the child's essential initiative, constituting the impelling influence in acquiring his ascendency over material things, has been induced to per-

sist as the same active agency in gaining a command of the intangible mental realm; and if the youth's sense of duty has been developed so far that he inclines to assume responsibilities in connection with his personal interests; then the information of the scholar normally grows into the knowledge of the student, and the latent capacity foreshadows the actual capability. The college is thereby enabled so to direct the student that the potential material accumulated in the school will not only be augmented with increasing definiteness, but also its pertinence and significance will become established by a systematic analyzing and comparing, testing and verifying, estimating and reasoning, correlating and coördinating of the intellectual store, as the mind matures.

A few generations ago the character of the necessary mental equipment was relatively simple; but with the rapidly augmenting aggregate of knowledge and the greatly increased complexity of human relations, the training of youth necessarily involves continually expanding obligations which the college alone cannot meet. With its services must be leagued the influence and aid of other interests, particularly that of the parents, in the mutual duty of encouraging and preparing a firm foundation of potential mental power. To be effective, this signifies the gradual and definite winning, by the student, of ability to comprehend the various interests, concerns, and influences which actuate men; of capability to realize, with growing penetration, the motives and aspirations which control humanity; and of power to discern, with maturing insight, the profound significance of this essential knowledge upon his own life's activities. Evident as such facts are to the man of affairs and to the efficient instructor, they are vague to the average youth. It is the awakening of his conscious perception to the reality of these obscure but vital truths which constitutes the essence of true college training.

The necessity is not so much to inform the student of bare facts, current practice, or mere details of social, commercial, or professional life; if such were the need, it would be better secured by active participation in such affairs. The actual worth of a college education lies, rather, in the opportunity to equip the student with those attributes of mind which will fit him to meet and solve successfully the various problems of life in a broad and sane way, as they shall be encountered, by disclosing to his developing perception (while it is yet plastic) the fundamental fact that all the activities of material and spiritual life are subject to law, whether it be clearly evident (as to the child who pays the penalty for carelessness in the pain of the resulting injury) or whether it be complex and obscure (as to the man whose character is a crystallization of the aggregate influences which he has embraced during all the preceding years). The real field and valuable work of the college

are concerned with the underlying principles producing an effect, rather than with only the evident result itself. When this broad grasp of fundamental truth is attained by the student, the essential work of the college is, for him, achieved; because experience itself is the ultimate teacher whose training is made definitely effective through the discipline of the college in refining the crude mind. Such breadth of training is attained with difficulty in the disjointed, fragmentary experiences of youthful employment; or by the bare, encyclopedic information imparted by some schools in which exists "the soul of evil in things good." The college exists for the essential purpose of vitalizing the student's knowledge by disclosing the fundamental truth of the rule of law in all the affairs of life.

The universe in all its relations is governed by law, much of which is known, and which is as definite as anything conceivable by the human mind. Eclipses are predicted with precision; the orbit of a planet, once determined, is known for all time, unless there should occur an improbable disturbance,—which is never fortuitous. The earth is subject to law, both in its structure and in its changes. By studying its phenomena we can determine the causes, operating through fixed principles, which produce the observed results; and the future is known from the past and present, with the precision in which the operating causes are determined, and until a remotely possible contingency occurs to introduce a modified order of things still obedient to law. By examining the structure of the world we can apprehend the history of the agencies producing it with an accuracy approximating the truth as closely as the observed facts disclose the principles which combine to affect the result. Here the essential truths are only partly mathematical, and the demonstrated conclusions are less absolute than those of cosmic motion. The principles of crystallization are fixed, but the form may be modified by the disturbing influence of other laws. So, too, with solution and deposition, liquefaction and solidification, pressure, stress, deformation, erosion, transportation, and all the phenomena of geologic development; the truth is discerned in the measure that all the contributing facts are correctly apprehended.

In the field of effort which utilizes the forces and resources of nature for the advantage of man, the structures and machines securing these benefits are developed through the application of principles very definite in their fundamental competency. Design is adequate to the extent to which all pertinent laws are apprehended and applied, and is doubtful only so far as some conditions are variable or vague.

In the living world the same fundamental operation of law governs, but often with less clearness, due to a freer opportunity for modifying in-

fluences to act. The basic principles of form, distribution, structure, growth, and function of plant life, and persistent modifications which finally lead to the development of new species and genera, are all manifestations of complexity which seem sadly confused, but which, when all the essential facts are determined, are finally seen to be the direct resultant of all the various laws concerned, each influencing the product in proportion to its pertinence. In the animal kingdom the same truths govern, but with increased intricacy due to various added factors, such as mobility, instinct, and sensation, producing a heterogeneous aggregate of effects that seemed baffling, indeed, until the great pioneers of research, each in a limited field, discovered that here also each phenomenon, small or great, whether it be the color of the fur or the recognition of evolution, is a product of interacting conditions and influences producing results in harmony with law.

What, then, of human life? Can principles control in all else but this? Rather do we know, in our physical existence, that cause and effect are as sure as in other realms of nature. We also apprehend the existence of a fundamental order and system in affairs of the mental sphere, whether it concerns a relatively simple thing, such as memory, or whether it involves complex combinations of various effects of the perceptions, the sensibilities, and the will. So, too, in the domain of morals do we anticipate the control of law in producing the effect, although the influence of the disposition, emotions, desires, and aspirations is so often exceedingly obscure. In the spiritual life we again infer the same essential rule of principle, governing in truth this realm so recondite and rare. The multiplicity of the contributing influences and the obscurity of many of the causes affecting a result often appear so chaotic that its systematic consideration seems quite hopeless; and yet it is the reduction of apparent chaos to its elements of actual order and law, in things small or great, which characterizes productive power.

The definite apprehension of this fundamental truth distinguishes true education, however secured. The college curriculum in its various courses utilizes facts and truths as the materials of its work; and the danger lies in adding indefinitely such materials of mere knowledge because their range is so illimitable. Yet real efficiency results only as thought is vitalized by training the student to a clear apprehension of the pertinence, relation, and significance of such facts to the varied interests of life's activities. The paints which the artist uses constitute the materials of his work; it is only when these materials are expertly spread upon the canvas, to disclose to others that picture which had been imaged solely in the artist's mind, that the cheap pigment becomes the priceless painting. In college the bare materials of study and experience are of

little value until transformed by thoughtful assimilation into a productive capital of order and principle, which reaches beyond the obvious surface of things and discerns the elemental factors and fundamental laws which produce the observed results.

How, then, can educational methods be vitalized? The details are infinite in variety, but the principles are simple. Teach in a broad, tolerant, tactful way constructively to develop the student's power of original observation, demonstration, and reasoning, even though it robs the teacher of the self-satisfying prestige of too frequently arousing the admiration of his class when he displays to the student those things which the latter should be trained to discover for himself. Teach to correlate and combine the essence of the scientific method (which is systematic exactitude) with that of classic study (which particularly trains for breadth and power) ; so that precision of analysis may be blended with such fulness of information and such readiness to use it that abstruse inflexibility and vague generalization may both be avoided; and so securing to the student a realization of that scholarly aptitude, efficiency, and poise which will lead to mastery, through method, in dealing with the varied experiences of life. Teach to make clear the distinction between an absolute truth and an inference, between a principle that is certain and one which is more or less conjectural; because the affairs of life are affected by uncertainties, varying in degree, and the result is certain only to the extent to which the contributing principles are definitely germane. Teach to develop mental discipline fundamentally; to conserve and fortify physical, mental, and moral vigor, which are the natural endowment of youth; to systematize and control effectively the distribution of time and effort, which furnishes the opportunity for attainment, so that the waste of procrastination and inadvertence may be avoided and a substantial mental capital be won. Teach to think so rationally that neither uncertainty nor intolerance results; to reason so clearly that knowledge shall not deteriorate into either barren information or pedantic speculation; to consider so discerningly that there is no room for vacillation or arrogance; to know so truly that learning shall not degenerate into either conjecture or dogmatism.

Ideals, such as these, are not Utopian. To the discerning teacher they form the standard toward which he ever leads, whose inspiration effectively pervades the daily detail of class work, giving vitality and heart to the duties which otherwise might lapse into automatic routine, and crowning sustained effort with recurring evidences of youthful lives responding to the spirit, as well as to the form, in college work. To the student so led, the college curriculum becomes revealed as a special opportunity for him to prepare for effective service; the true significance

of his duties is disclosed as he increasingly realizes that it is his personal, discriminating, constructive endeavor which secures for him a potential power readily available for effective use; the college interests assume a larger import as he discovers that the personal influence of his class-room guides, while insisting on thorough and faithful study, also encourages those collateral activities of wholesome college and social life which effectively supplement class-room work in developing a broad, well-balanced character; and the discipline of his various tasks is given point and purpose as he grows to distinguish the vital principles disclosed through their mastery. The way is open for the youth to become the man, for capacity to attain capability, for enthusiasm to expand into zeal, for power to achieve command, and for knowledge to develop into wisdom, as the opportunities of active life shall give form and substance to his intent.

CLOSING LECTURE TO SENIOR CLASS.

By

Professor Vladimir Karapetoff.

The appeal of this address should reach directly to the heart of every newly fledged engineer; for its sound rings true, and the correctness of its dictum cannot be gainsaid. It is not every professor who will risk losing popularity with his students by talking plainly to them, as Prof. Karapetoff does, concerning matters purely personal and not in any way connected with the curriculum. All honor to him, then, for his courage and his broad-mindedness; and may he long continue to discourse to young men concerning the ethics of life and the moral responsibilities of students and engineers!

Editors.

CLOSING LECTURE TO SENIOR CLASS.

By

Professor Vladimir Karapetoff.

I have delivered the last lecture in your course but there is still one more to give you that is not usually included in works on electrical engineering. It is on the text: "Cash up" or to be more literary, "pay your accounts."

You soon shall hear plenty of advice in regard to the wisdom of life. I wish to impress on your minds that you cannot start your life aright until you shall have closed your present accounts. Pay your debts. Return that borrowed book and those other articles, such as golf sticks, tennis rackets, and the like. Also repair all damage that you have done purposely or inadvertently. Do this so that you can look every man, woman, and child now in Ithaca straight in the face. But this is merely the beginning of the closing of your accounts, the "prelim."

See other students with whom you have had some difficulty or "contre-temps," shake hands and say you are sorry for the mishap and that you wish the slate wiped out. Then there are other '09 men and women against whom you felt somewhat distant or hostile, perhaps on account of differences in temperament, tastes, or finances. Was it due to a bit of jealousy?

Well, are you not afraid to carry a big burden all through life? Better go to those you liked the least, clasp both their hands (allegorically if you like) and look into their eyes. Look, I say and look again, and as you are looking, the sham images that your mind created will gradually disappear. Then you both will see each other in the true light as perfect children of God, trying each to solve his or her life's problem to the best of one's understanding. You should do this moreover, for you need each other's help and sympathy.

Do you still begrudge your landlady the small things that she did or neglected to do? How about yourself? What about your omissions and commissions? It is all over now. Soon will you shake off the dust of Ithaca, but before doing so tell your landlady that you are sorry about that disturbance you made and the broken chair that resulted and also the small fire started by throwing lighted matches in

the waste basket. Also the damage you did to the wall by driving nails to hang up those interesting pictures. But above all be actually sorry. Don't sham about it.

The Faculty and the registrar certainly did not treat you right on all occasions, for they are human, of course. What are you going to do about it? Are you going to poison the joys of coming years by carrying such reminders home with you? Settle your accounts now and for all time as far as Ithaca is concerned. A great Russian writer has well said, "To know all is to forgive all."

Put yourselves in their places and see if you cannot allow some extenuating circumstance. If not, live the same occurrence over again in your mind and imagine the guilty person to act right. Then whenever you remember the incident later on always see it in the ideal light. In this life of ups and downs, play for the ups and ignore the downs.

Do not be in a hurry to leave Ithaca. Close first the university life's account. For several days after you have finished your work here go up to the campus, sit down under a spreading tree on the quadrangle and watch calmly the procession. Recall the memories of the days gone by and live that university life over again. Live it in the true ideal way and then leave Ithaca as men, reconciled and refreshed, prepared for the active, the energetic, the truly efficient life.

THE HUMAN SIDE OF THE ENGINEERING PROFESSION.

By

Professor Vladimir Karapetoff.

The place of honor in this collection of addresses is reserved for Prof. Karapetoff's thoughtful and masterly presentation of advice to young engineers. In no other writing have the Editors ever seen so many sound precepts in such a condensed form. All that is said is so terse, so true, and so appealing that one cannot but admire the author's thorough conception of both the practical and the ethical life. No thinking man can peruse this address without desiring to read it again and again; and each time he reads it he will receive new benefit.

No man could conceive such profound ideas and use such stirring words as these without truly feeling and meaning them from the bottom of his heart; and although the Editors have never yet had the pleasure of making Prof. Karapetoff's acquaintance, they desire here to express their appreciation of him as a writer and as an ethicist, also their hope that he will continue in the future to give to the world the benefit of his earnest thoughts and lofty ideals in relation to the rules of conduct which should govern engineers in their dealings with each other and with the community in general.

Editors.

THE HUMAN SIDE OF THE ENGINEERING PROFESSION.

(AN OUTLINE.)

By

Professor Vladimir Karapetoff.

FUNDAMENTAL THOUGHT:

Professional usefulness and personal satisfaction depend on the right. conception of life and on the degree in which this conception of life is manifested in daily activity.

PART I.—WORK AND CONDUCT.

There are three essential requisites for an efficient and successful engineer:

A. Sound professional knowledge;

B. Knowledge of business forms and of human relations;

C. Good and strong character.

A. PROFESSIONAL KNOWLEDGE. A man who knows only "how" to do certain things, but does not know "why" they are done so, usually remains in subordinate positions. Get into the habit of analyzing; also, have your knowledge systematized.

In order not to get "rusty," you ought to do some study, or at least some reading outside of your daily routine work. This outside work may be classified, in an ascending scale of difficulty, as follows:

1. Keep notes on your regular work, with sketches, samples of calculations, etc. On separate notes keep matters of doubt to straighten them out at a future opportunity.

2. Read regularly at least one periodical relating to your specialty, and keep some kind of a general index on at least one subject in which you are particularly interested.

3. Be sure about the fudamental laws, facts, and assumptions on which your branch of engineering is based. If you are but recently from college, you can go over your old books and notes; otherwise read a good modern text book.

4. Gradually get familiar with more advanced books treating of the various branches of your profession; go from time to time to the public library and see if there is anything new in your specialty.

5. Select some one branch of engineering, if possible, somewhat different from that in which you are regularly engaged and devote some time to it. Know more than the next fellow does; it will pay you.

6. Do not miss any chance to make an original investigation; this will develop your thinking, increase your self-confidence, and raise your standing in the profession.

7. Inventing is the highest form of engineering activity; there is no reason why you should not bring some improvement into the work in which you are engaged. Concentrate your mind on one thing, work patiently and persistently, and you will be sure to achieve something that will be new and useful.

B. *Knowledge of Business Forms and of Men.* You naturally expect some day to occupy a responsible position in your profession. This is impossible without a sound knowledge of established business forms and of human relations in general. Here again there are several stages of study and observation. Take up as many of them as your ambition, time, and ability will allow.

1. Observe the characters of men you are working with; in particular, the influence of their previous experience and education, of their age and temperament, of their views on general life questions, etc.

2. Observe things that make them efficient and happy, or that are impediments in their work; things that they would like to have and the main things that they object to.

3. Observe critically your superiors and their ways of acting towards their chiefs and subordinates. Do this without malice, but rather with a sincere desire to find out the best way of conducting the work, when you shall be called to perform their duties. Make for yourself a clear mental picture of an ideal man in a certain position, and try to follow this ideal in your own business life.

4. Observe and read about general business systems adopted in large modern commercial and industrial enterprises; in particular,

(a) Subdivision of the duties of various officers, and their correlation;

(b) Correspondence, accounting, orders, receipts, etc.;

(c) Causes of loss, waste, inefficiency, etc., and possible remedies.

Merely knowing the facts is not sufficient: you must see clearly the necessity for a certain organization. Only then will you find a right place in it for yourself and efficiently discharge your duties.

5. Do not get "rusty" on general life questions; read books on history, economics, philosophy, etc., with the view of finding the underlying facts and motives in human relations. Do not adhere too readily to a traditional school; work out your principles for yourself, and be willing to change them when new evidence is laid before you. A man in a responsible position must be a well educated man; he meets a great many men, and has to face new situations. Therefore he must be well

informed on things in general, and ought to be able to judge about them.

C. *Training of the Character.* Engineering and business knowledge are the necessary conditions for usefulness ("success" and usefulness are not always the same), but the proper development of the character is the third necessary condition.

What is the use of having a profound knowledge of engineering, if you have not the necessary perseverance to achieve results; or to have a knowledge of business forms and relations, if your temper is such that nobody cares to be associated with you in business?

Practice daily the qualities of the character that you find essential for a good citizen and a good business man.

1. Work patiently on any problem until a result is achieved. If it should be impossible to get satisfactory results, at least make clear to yourself the nature of the hindrances.

2. Be honest in all things; do not be afraid to confess your mistakes or your ignorance. Train your character by doing your work over cheerfully.

3. Keep down your selfish personality and ambition. Do not let them interfere with your business. *The highest goal of personality and ambition is to have your part of the work done in the most ideal way.*

4. Be generous, polite, and considerate to others; there are no circumstances where you would be justified in breaking this rule. Remain dignified even under unjust reproof.

5. Work with the understanding that your activity of to-day shapes your future. You need not trust to chance; *your opportunity will come when you are ready for it.*

PART II.—UNDERLYING MOTIVES.

(A THEORY OF LIFE.)

Some men are happy and efficient in their work without having any clearly defined conceptions of life and its purpose. In a great majority of cases, however, a lack of a workable theory of life brings with it a decrease in possible efficiency and in personal satisfaction. It is of importance, therefore, to know

- A. What are the principal limitations and wrong beliefs that are hampering engineers in their work.
- B. How these limitations can be removed by working out a theory of life that gives a general meaning to man's activity.
- C. How an engineer's work is shaped, when his underlying motives are illumined by such a theory of life.

A. USUAL LIMITATIONS that prevent an engineer from being fully efficient and happy in his work.

1. Belief that he is underpaid; abnormal striving after money.
2. Belief that his efforts are not appreciated by his employer; also that there is no chance for promotion.
3. Lack of knowledge, theoretical or practical; lack of general education; a deficient knowledge of business forms and human relations. This is often accompanied by a belief that he has no time for study; in cases where a man has not exercised his mind for a long time, he has also to contend with his own mental apathy.
4. Deficiencies in character, such as weakness, roughness, egotism, narrowness, pedantry, absent-mindedness, laziness, etc.
5. Lack of enthusiasm due to the absence of a guiding and unifying purpose in life. This is particularly noticeable in very young men who are just beginning to form their own conceptions of life, and in older men who already see the end of their usefulness and cherish no more illusions.

B. A Theory of Life. Each man must work out for himself a practicable theory of life; this will make his acts and words, thoughts and feelings, harmonious and consistent. The experience of humanity past and present is the material to work on; his reason is called upon to interpret this, and his conscience is the court of final appeal.

The following is *an example* of such a theory of life: (*)

1. The Universe, including man, is governed by an infinite intelligence, which is manifested in man as his conscious life. There is no meaning in a man's life if it be detached from other men's lives. In proportion as he becomes conscious of this one, infinite life, common to all men, his own life becomes reasonable and harmonious, and the fear of poverty, sickness, old age, and death gradually disappears.

2. The highest purpose of life is to work for the realization of the above ideal conditions of life on earth. We do this either by actually removing certain hindrances and fetters (practical work), or by making this great work clearer to others (literary, educational work, preaching, etc.).

3. Once this attitude is understood, the real compensation for the work consists, not in money and notoriety, but in the state of consciousness reached. This is manifested in particular:

(*) It may seem presumptious on the part of the writer, who is not a philosopher by trade, to formulate a "theory of life"; this he gives, however, simply in order to illustrate what a practical doctrine of life (not a "canned" religion) may be. For the author personally this doctrine is the truth he believes in and according to which he tries to shape his life; for others it may serve merely as an example. He hopes that by criticizing his metaphysics readers may make their own conceptions on the subject clearer to themselves, and in this way be indirectly benefited even by a theory presumably wrong.

(a) In a clear and definite program of life, and a ready answer for all difficulties (doing your best).
(b) In a state of harmony and good fellowship with all men, through the understanding of that life which is common to all.
(c) In a freedom from fear, anger, jealousy, apathy, and other limitations caused by the assumption that life is an accidental chain of phenomena and circumstances.

C. Work Illuminated by Higher Ideals. Once he has obtained a workable life-theory, all of the limitations enumerated above that prevent an engineer from being efficient and satisfied in his work can be removed by actually applying this theory to his daily work.

1. The belief that he is underpaid or not appreciated enough loses its power; the man works no more for a company or a corporation. He works for his conscience's sake, and finds his true compensation in the results of his work.

2. He is full of desire to do as much as he can, and not as little as he is allowed to. For this reason he wants to know much and to have his knowledge in a practical form, ready for use. He is active and studious all the time, and the expression "mental lethargy" is incomprehensible to him.

4. He frees himself from possible shortcomings in his character by keeping the ideal of perfection continually before his mind's eye. He no longer finds difficulty in handling men and in treating his co-workers and chiefs aright; he has a sincere sympathy for them, tries to help them, and to make their work more pleasant and efficient.

5. He is full of enthusiasm, for he is aware of the infinite importance of his life and work. His work is infinite as is Life itself; and each problem solved brings with it a higher and more important problem, brings more truth and light into his consciousness.

Conclusion—(*Credo*).

1. Make yourself ready for a broader and higher field of activity; then your opportunity will surely come.

2. The true purpose and value of engineering activity lie in providing better and easier ways for satisfying ordinary human needs. This provides more leisure and opens new possibilities for a higher spiritual and intellectual development of humanity.

3. The engineer's personal satisfaction consists in knowing this high purpose of his vocation, and in giving his service at a maximum efficiency. The other compensation is a result and not the purpose.

FINIS.

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